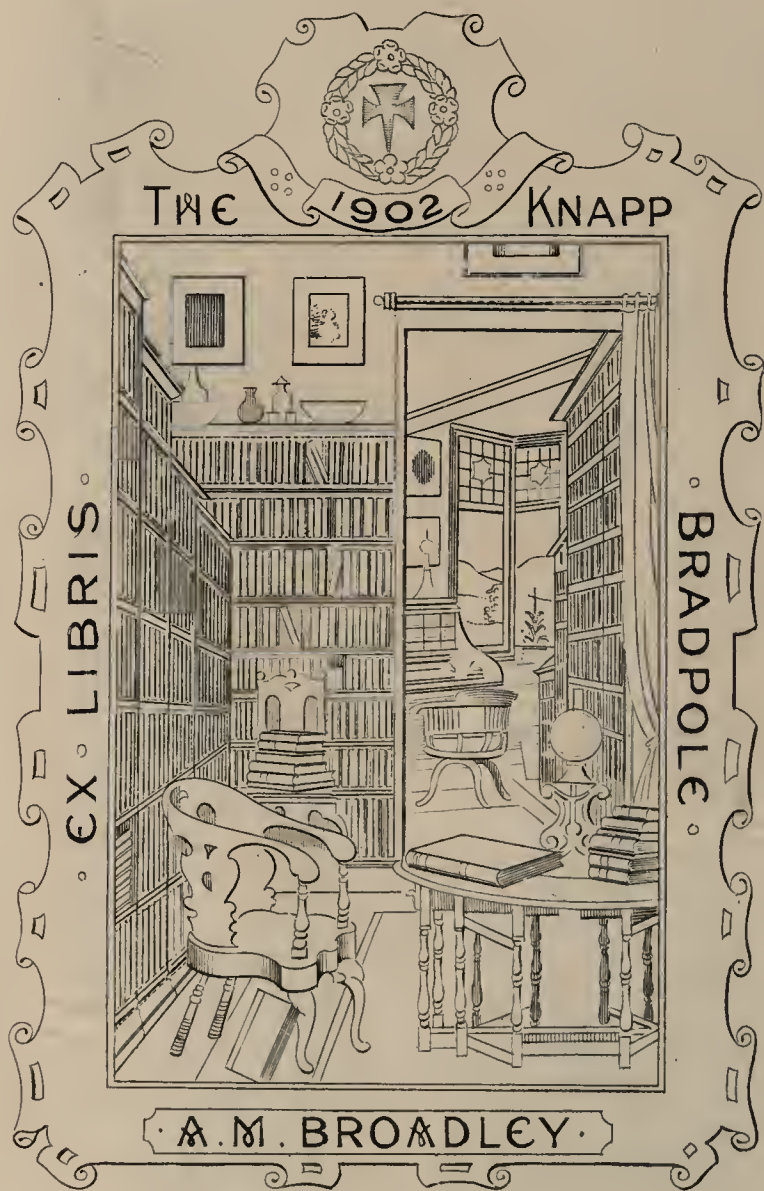
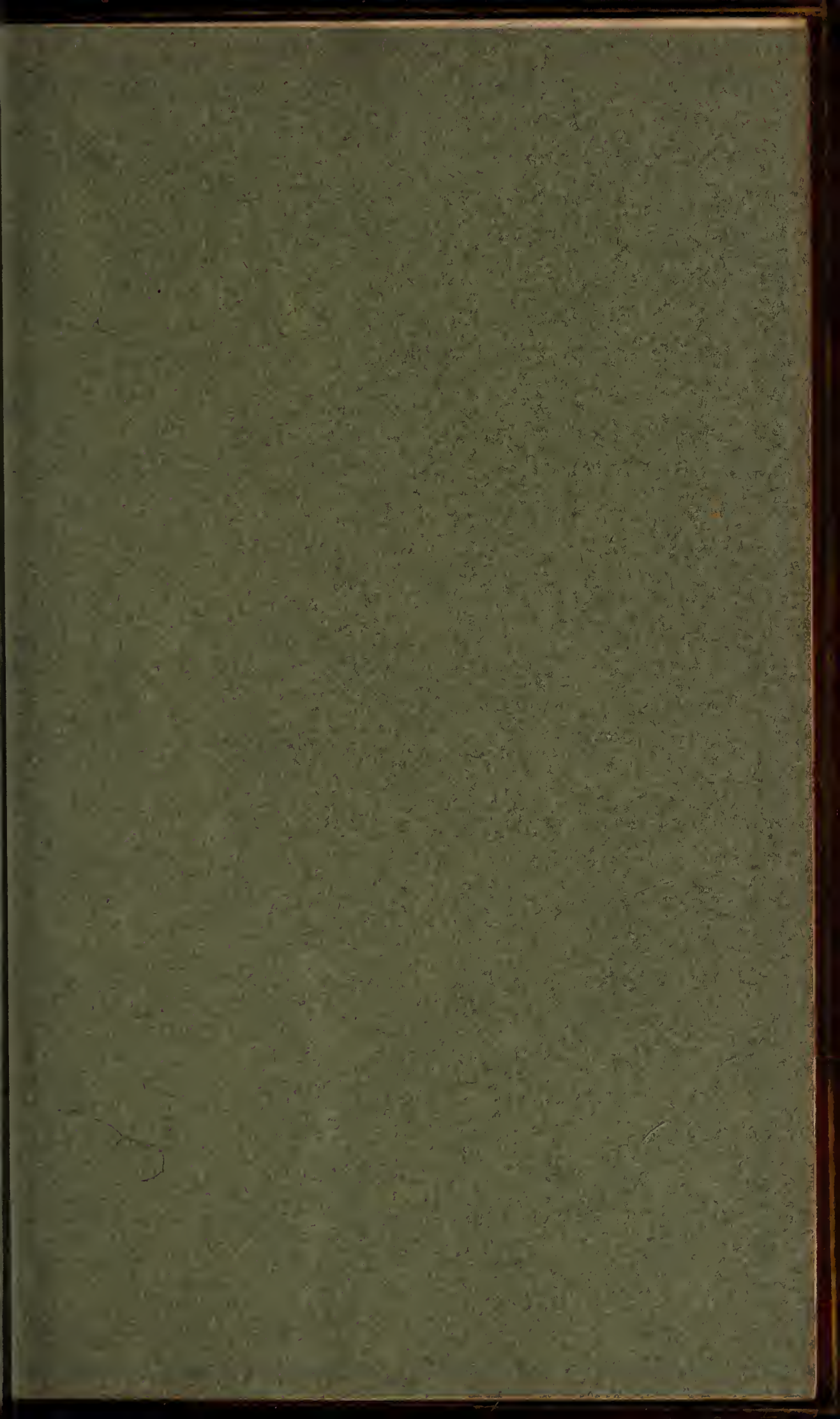




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# ANALYTICAL RESEARCHES

INTO THE PROPERTIES OF THE

## Bath Waters,

With a View of evincing a Similarity in the Chemical and Medical Properties of the various Springs which supply the Kingston Pump-Room and Baths, the King's and Queen's Baths, Great Pump-Room, and Hot Baths;

BEING

### THE FIRST COMPARATIVE ANALYSIS MADE OF ALL THE HOT SPRINGS:

*And from which is deduced that they are Ramifications  
from one grand unknown Source.*

To which are subjoined,

### OBSERVATIONS

ON

### *AFFECTIONS OF THE SPINE,* HIP-CASES, HERNIÆ, CLUB-FEET, &c.

EVINCING THE ADVANTAGES TO BE DERIVED FROM  
THE PRINCIPLES OF MECHANISM.

C. H.  
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TO THE  
RIGHT HONORABLE EARL MANVERS,

AND TO THE  
HONORABLE VISCOUNT NEWARK,

THE FOLLOWING

*Analytical Researches*

INTO

THE PROPERTIES OF THE BATH WATERS,

AND PARTICULARLY OF

THE KINGSTON WARM SPRINGS,

WHICH APPERTAIN TO THEIR LORDSHIPS' ESTATE  
IN THIS CITY,

*ARE MOST RESPECTFULLY INSCRIBED*

BY THEIR LORDSHIPS'

MOST OBEDIENT

AND DEVOTED SERVANT,

C. H. WILKINSON.

KINGSTON-HOUSE, BATH.



# CONTENTS.

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## CHAP. I.

	<i>Page</i>
ON the Springs which supply the Kingston-Baths .. ..	1
On these Springs the first private Baths were made ....	3
An Open Bath objectionable ..... ..	5
No immediate Connexion between any of the Hot Springs	7

## CHAP. II.

On the Temperature of the Bath Waters .... ..	9
All the Springs at the same Level of the same Warmth ..	10
Pyrites not the Cause ..... ..	11
Depends on the Depth below the Surface of the Earth ..	14
The Cause of Difference in the Cross-Bath .. ....	23

## CHAP. III.

On the sensible Properties of the Bath Waters ..... ..	24
The Capacity for Caloric not greater than common Water	25
On the Gases contained in the Water ..... ..	30

## CHAP. IV.

On the Examination of the Bath Waters by Tests and Re- Agents ..... ..	32
All the Springs, except the Cross-Bath, the same as to their solid Contents ..... ..	39

## CHAP. V.

	<i>Page</i>
On the proportionate constituent Parts of the gross Contents of the Bath Waters .....	44

## CHAP. VI.

On the Silex and Carbonate of Iron .....	58
Silex not acted on by artificial Heat .....	60
Silex not sensibly soluble in Water .....	61
When discovered in Water, only mechanically suspended	63
Silex, either simple or compound, no medical Properties..	64

## CHAP. VII.

Carbonate of Iron .. .. .	65
Carbonate of Iron volatilized by Carbonic Acid .. .. .	66
Probably some Effects on the Lungs .....	69

## CHAP. VIII.

On the Sand and Organic Remains .....	70
Observations on the Pyrites and Nuts .. .. .	71
Not evolved by the Spring, but alluvial .....	72
Dr. Falconer's Remarks on the Cross-Bath .. .. .	73
On the Elevation of the different Baths .....	74

## CHAP. IX.

On the Agency of the Bath Waters internally .. .. .	75
Caution as to the drinking them .....	77
Most Diseases originate in Intemperance in Eating .....	78
On the Increase of Paralytic Affections .....	81

# CONTENTS.

vii

	Page
On the Poisonous Effects of Lead, and the various Means by which that Metal is introduced into the Constitution	83
Dr. Falconer's Remarks on the Leaden Cisterns at the King's Bath .. . . .	84
The Kingston Pump-Room has no Lead connected either with the Pump or the Reservoir . . . . .	85
On Vicissitudes of Temperature as influencing the Body ..	87
The Properties of the Waters preserved when not less than 100 Degrees; hence a slight Difference of Warmth at the different Pumps of no Consequence .. . . .	90

## CHAP. X.

On the Influence of the Bath Waters externally employed	92
In what Diseases they are beneficial . . . . .	94
Warm Bathing acts by equalizing Temperature .. . . .	95
On the Advantages of the Flesh-Brush . . . . .	96
On the Construction of the Dressing-Rooms of the Kingston- Baths to prevent any Current of Air .. . . .	97
Advantages arising from each Person having a fresh Bath	98
On Tepid Baths . . . . .	99
On Dry Pumping . . . . .	100
On Mechanical Support to the Paralytic Hand .. ..	102
On the Use of Electricity . . . . .	103
On the Shower-Bath . . . . .	105
On the Treatment of Gutta Serena, and in what Stages of the Disease Galvanism is beneficial . . . . .	106

## CHAP. XI.

Remarks on the Influence of elevated and low Situations ..	108
--	-----

## CHAP. XII.

On Incurvations of the Spine . . . . .	114
On Incurvations from Debility . . . . .	118

	Page
On Incurvations from Local Injury      . . . . .	120
On the Treatment of Spinal Diseases      . . . . .	125
On the Influence of heavy Weights on the Head      . . . . .	126

## CHAP. XIII.

On the Wry-Neck      . . . . .	129
On the Construction of Trusses for Herniæ      . . . . .	131
On Diseases of the Hip-Joint      . . . . .	133
On Club-Feet      . . . . .	137
Terms of the Kingston-Baths and Pump-Room      . . . . .	145

## PREFACE.

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NOTWITHSTANDING the valuable dissertations which have been given on the Bath Waters by Drs. Lucas, Charlton, Falconer, and Gibbes, and by Mr. Phillips, yet an opinion has been entertained that the Hetling-court or Hot Baths, the Cross Bath, the King's Bath, and the Kingston Baths, differ in their properties: from a careful examination of all these waters, I have presumed to submit to the public the following observations, with a view of evincing that they all arise from one common source, and of pointing out the cause why the Cross Bath possesses a diminished temperature, and a relatively less proportion of saline matter.

The general properties of a mineral water are easily ascertained; but to exactly appreciate the quantity of each ingredient is not so easy a task as might at first be imagined. We rarely find the analysis of a mineral water, conducted by two different persons, either the same with regard to the mode adopted, or the results coinciding; and in many instances the analysis by the same person, at two distant periods, will frequently differ. From the nature of my professional engagements at Bath, the warm springs of this city have frequently been the subject of my examination; and, at different periods, I have evaporated considerable quantities of the water, with a view of estimating the proportion of solid matter held in solution; and as in many instances the quantity has not appeared precisely the same, it is from the mean of these experiments the estimate of the constituent parts held in solution is made.

Mayow, whose name in the annals of chemistry ranks so deservedly high, has evinced a correctness in his examination of these waters superior to any of his contemporaries; yet his essay was neglected,

from the illiberal observations in the absurd production of Guidot.

The existence of nitre and of sulphur in the Bath Waters was deemed so evident, that the medicinal effects were attributed to these ingredients. Mayow, with that acumen peculiar to himself, completely proved that no such constituent parts entered into the composition of the Bath Waters: "*Quod ad nitrum et sulphur attinet, quibus thermas Bathonienses imbutas esse hactenus creditum est, eorum neutrum aquis thermarum istarum solutum esse arbitror.*" He remarked that the salts, which remained after evaporation, possessed no deflagrating power; and that the yellow tinge given to silver by the Bath Waters was a trick of the guides, and which was more completely developed by Dr. Lucas.

The impudence of Guidot so completely prevented the observations of Mayow producing any effect on public opinion, that when subsequently Dr. Lucas demonstrated the correctness of Mayow's inquiries, he informs us that the trustees of the institution, apprehensive that the developement of

these circumstances might be injurious to the baths, offered him a considerable fee to suppress his observations.

Drs. Falconer and Gibbes's essays are each replete with valuable observations; and the respective analyses are conducted with all the skill which the then existing knowledge of chemistry admitted. Every day some new test or re-agent is discovered, some new laws as to chemical combination developed; and, in proportion as we make this progress, so are we enabled to appreciate with more correctness the constituent parts of any compound substance: but we are by no means authorised in supposing ourselves now arrived at such chemical perfection, as to be enabled to resolve with accuracy any material compound into its chemical elements: this is strongly illustrated by a review of the examinations of the component parts of sulphuric acid, and the sulphates of lime and barytes, by Klaproth, Vauquelin, Richter, Kirwan, and Thomson, in which no two exactly coincide. If then such be the case with these superior chemists, with what diffidence ought any analysis to be submitted to the public,

when found not to accord with the previous observations of other men.

The greater number of mineral waters with which we are at present acquainted, we are capable of imitating; and we are also enabled to make those artificial arrangements which will produce entirely the same effects on the constitution as the waters from their native springs. Thus, the Seltzer, Spa, the Pyrmont, the Aix-la-Chapelle, the Harrogate, and the Cheltenham, we can form at pleasure; and, if any difference, superior, in a medical point of view, from their being divested of the inert and inefficient portions, as the sulphate and carbonate of lime, &c. With respect to the Bath Waters, all attempts which have been made to produce artificially a similar arrangement, inducing corresponding effects on the constitution, have failed. I have re-dissolved its own precipitated matter in water raised to the same temperature, but the effects by no means coincide.

To none of the constituent parts which have been ascertained are we to attribute the general

effects of the Bath Waters. In the dose, usually taken, the quantum of the muriate and sulphate of soda which, with a very minute portion of iron, constitute the only active part of the solid contents of the water, could not affect the most delicate infant: to the existence of some other principles we must ascribe the efficient power; and it appears to me to arise from some peculiar and unknown combination of caloric with water, combined with a super carbonate of iron in a volatile state.

## ON THE SPRINGS WHICH SUPPLY THE KINGSTON BATHS.

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**T**HE earliest account we have of these springs is derived from Solinus about 1700 years since. He alludes to some hot springs which were dedicated to Minerva; and it appears that the temple of that goddess existed on the same spot where the Abbey-church now stands. Solinus describes these baths as very elegantly constructed, but no traces of them were discovered till the year 1755. During the disturbances in the Saxon period, the splendid buildings forming the Roman baths were destroyed, and only a traditionary account of them existed.

At the dissolution of monasteries in 1544, the government of the city and baths fell into the hands of the laity; and in 1590 Queen Elizabeth, by charter, granted a perpetual lease of the then known baths to the

corporation, as trustees for the public, and not as owners. About the same time the priory estate became the property of the Kingston family. In the year 1755, after taking down the Abbey-house, and sinking for a foundation for new buildings, the ruins of some very elegant Roman baths and sudatories were discovered; so that little doubt remained but that these were the sumptuous baths mentioned by Solinus, as their structure accorded with the elegance of that luxurious and refined people. Dr. Lucas had an opportunity of seeing these ruins, in such a state as to enable him to give a very adequate idea of the building anterior to its destruction. The large bath, 33 feet by 18, was placed in the centre of a splendid room, supported by 16 columns, some of the plinths of which now remain; at the end of this room was a semicircular bath, more elegantly constructed, and apparently appropriated to the use of the patricians. These rooms communicated with two *hypocausta*, *laconica*, or sudatories, each formed of two floors, and between them flues were constructed, through which heated air passed into the room. That these were built by the Romans is evident, from the circumstance of the ancient Britons not being acquainted with the method of building with stone, brick, and mortar; whilst the Roman baths were constructed on the most extravagant scale; for Seneca, Pliny, and Statius, have described them as being lined

with silver, the seats formed of solid silver, and the pipes through which the water flowed as composed of the same metal:—" *Nil ibi plebeium: nusquam temesæ videbis æra, sed argento felix propellitur unda argentoque cadit, labrisque nitentibus instat delicias mirata suas et abire recusat.*"

That the Kingston or Roman Baths were built long before any erection on the other springs is evident from their different elevations, the bed of the King's Bath being more than 10 feet higher than the bed of the Roman or Kingston reservoir,—a proof that the King's Bath has been formed since this part of the town has been raised, and consequently on an artificial soil; whilst the Kingston springs flow immediately on the blue argillaceous stratum.

On these springs the first private baths were made, although constructed on a contracted scale; yet they excited so much public attention, that the trustees of the other baths adopted a similar plan. When these springs came into my possession, I considerably enlarged the baths, which, in point of convenience, are not excelled by any in this kingdom. As the baths are sunk below the reservoir, they are rapidly filled by the water's columnar pressure in the space of six minutes; and as the source from whence they arise is extraordinarily abundant, a fresh bath, containing twenty hogsheads of water, at any required temperature, is given to each person.

It has been imagined by some persons that the Greeks and Romans, in the construction of their baths, have evinced only an imagination fertile and extravagantly romantic, without mental energy, indulging a voluptuous languor, and consulting only the “pomp of the eye and the feast of the sight,”—οφθαλμων πανηγυρις, εορτη οψεως. Such a supposition could never have occurred to an unprejudiced mind, who had ever experienced an opportunity of contemplating these noble reliques of antiquity, and of investiagting the principles on which they were formed. When we compare the present edifices appropriated to this purpose with the majestic structure of the ancients, how poor in design are the former! how mean in the execution!

It has frequently been suggested to me to have the reservoir open for the purpose of general bathing, constituting what is called an open bath; I have always opposed such suggestions, from the following motives:—

The temperature of an exposed reservoir of the Bath Waters is proved to be, near the source, 104 degrees; whilst at the boundaries it is about 97 or 98. In most complaints, where warm bathing is beneficial, the alteration of a single degree, when above the temperature of the animal body, produces very marked and distinct effects: the nice adjustment of temperature requires the physician's most minute attention. Under such circumstances, an individual is allowed, without any directing

hand, to indulge in a play of temperature of six or seven degrees, and which frequently induces great constitutional disturbance.

Independent of this varying temperature as to the water, there is another variation of equal importance, to which different parts of the body are at the same time exposed. Thus, in cold frosty weather, whilst the lower part of the body is immersed in water at the temperature above mentioned, the head and the upper part of the body are exposed to a very material change as to warmth; it being well known that evaporation from any fluid is in the relative ratio of the warmth of the medium, and of the surrounding air: this evaporation tends to additionally cool the surface of the water, and renders the fluid mass of an unequal degree of temperature: the effects of such vicissitudes are well known to every practitioner. It was this circumstance, as to bathing, that the ancients particularly attended to; for, in order to guard against such changes, they went from the warm bath to the *hypocaustum*, and thus gradually prepared themselves for an atmospheric exposure.

Independent of temperature, a bath, constructed for the indiscriminate bathing of men and women at the same time, precludes several advantages that might otherwise be derived from it. In many affections, more benefit is experienced by a person bathing without any covering; and to gentlemen it is at all times more agree-

able, particularly in all cutaneous affections, where the active application of the flesh-brush is required. In a general bath this is necessarily inadmissible.

Independent of any objection as to promiscuous bathing, it is equally so in a medical point of view. A variety of persons, labouring under different complaints, all immersed at the same time, in the same medium, is, with respect to the constitution, more injurious than even respiring the confined atmosphere of similarly afflicted individuals.

With respect to the Kingston springs no such objection can possibly exist; for the reservoir which supplies these baths and pumps being entirely closed, the springs rise up in two distinct apertures, with the same gaseous evolution as observed in the other springs: from this arrangement the baths are filled with pure water, not determined from a repository which has already been subservient to the bathing process. The stream which supplies the Kingston pump-room is derived from the same pure source, unsullied by any adventitious circumstances.

It has been asserted by some, that the springs which supply the Kingston Baths are only branches from those appertaining to the King's Bath. These springs have no direct communication with each other, only indirectly, as emanating from the same source,—no other communication than what would exist between two pipes placed in

different parts of the river Avon, undergoing changes as the source varies.

It might, with the same propriety, be said that the King's Bath springs are supplied from the Kingston: the same power that would influence the one could only influence the other, by acting on the source from whence they both originate. That the ramifications have no immediate connexion were clearly demonstrated by the late attempts of the trustees to relieve their springs from the great quantity of alluvial matter which constitutes their present bed; and although the springs were exhausted nearly twenty feet, yet the Kingston Baths were filled as usual.

In these remarks, I hope it will be understood that it is by no means my wish to depreciate other institutions, with the illiberal view of elevating my own. I have deemed it necessary to state the above circumstances, from having been informed that some persons, whose opinions are fancied to be of importance, have propagated an idea that the Kingston Baths have no independent spring; an idea originating in ignorance, or probably from a servile motive of endeavouring to benefit other institutions at the expense of this. There are many persons in this city who examined the reservoir with me when it was last opened; and as the reservoir will be

examined every summer, it will then be opened to the examination of every person desirous of seeing these remains of Roman structure, and the direction in which the springs enter the reservoir.

The abundant supply of water from all the springs amply answers every intended purpose; our principal object therefore should be, to employ it in the way which may be most beneficial to society; not to contemplate the possession of such a spring merely in so mercenary a point of view, as to preclude the exercise of those feelings which the afflictions of the more unfortunate part of our fellow-creatures should excite.

What employment can he have worthy of a man, whose mind is occupied only about things low and base! and who grovels in a narrow field of mean, unanimating, and uninteresting objects, insensible to finer and more delicate sentiments, and blind to those more enlarged and nobler views which elevate the soul, and make it conscious of its dignity!

Let our attention be directed to objects of higher moment than the petty details of private regulations, or the preservation of any selfish monopoly. Let that benevolence which is the sublime character of our religion, and that freedom which is the basis of our laws, be extended, as far as circumstances will admit, to the relief of all who are immediately under our protection.

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CHAP. II.

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OBSERVATIONS ON THE TEMPERATURE  
OF THE BATH WATERS.

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**T**HE rude and imperfect method adopted as to the admeasurement of heat, prior to the introduction of the thermometer, prevents us ascertaining whether the warm springs of this city have undergone, from the time they were first discovered, any alteration as to temperature. From all the circumstances which have been recorded relative to these springs, there is reason to believe that no material change has taken place. Forty-five years since, the late Duke of Kingston requested Dr. Falconer to examine the springs appertaining to his estate; and Dr. F. observed the temperature to be  $114\frac{1}{2}^{\circ}$ ; last year the thermometer marked the same degree. In these examinations the thermometers were

placed close to the spring, and not let down to any depth below the surface of the bed.

When the thermometer is sunk 12 or 14 feet below the bed of the King's Bath springs, the temperature is  $115^{\circ}$ , and some have imagined it to be  $116^{\circ}$ ; but this error originated from the oblique direction in which the instrument was held. Dr. Gibbes, who has paid very considerable attention to this subject, observes that the temperature of the King's Bath, and of the spring at Hetling-court, is  $114^{\circ}$ ; when the reservoirs are filled, the temperature of the water directly over the King's Bath spring never exceeds  $104^{\circ}$ , whilst the waters in the reservoir of the Kingston Baths remains at  $108^{\circ}$ , the difference arising from the reservoir of the latter being closed.

The near uniformity in temperature of these springs, and the exact coincidence of their constituent parts, combined with their proximity, are proofs of there being only one common source to all. From whence arises the regular and invariable warmth? has long been a subject of inquiry; some have supposed it to arise from a pyritical decomposition, or to some change in the capacities for heat in those substances which are held in solution by the water; but there are no traces of any such pyritical matter undergoing these changes so as to produce an increase of temperature. If we were to suppose any sul-

phuret of iron occasioning by its agency on water a decomposition, there would remain a difficulty in comprehending from whence could arise, in a subterranean cavity, any combination of the nascent hydrogen with oxygen to form water; as, in the change of condition of the oxygen from its gaseous state, to form a constituent part of water, the caloric is evolved.

It is well known to those who have paid attention to chemical pursuits, that the first portion of sulphur in the sulphuret of iron, which becomes oxygenated, will, from its agency on the residual portion, produce the sulphurated hydrogen gas, a gas readily absorbable by water, the existence of which in the Bath Waters the most delicate test no way evinces. Supposing the Bath Waters during their circulation to flow over any pyritical beds, the sulphate of iron, which is a very soluble salt, ought to be detected in the Bath Waters, which is not the case: also, from the constant waste during the course of ages, some changes as to temperature ought to have been observed, which, from analogy as to no sensible alteration for these last fifty years, we may presume has not been the case. The substances which are traced in the Bath Waters could not, from any of their known properties, be deemed the cause of such an invariable temperature; it is more probable that the increased tem-

perature is first acquired, by which the water is enabled to act more powerfully on the strata over which it passes, and thus detaches a greater proportion of saline matter than it otherwise would.

By some it has been supposed that there is a subterranean fire, and any springs flowing near this mass of caloric would become proportionally heated. Thus, Dr. Darwin imagined that the same fire which heats Vesuvius warms the springs of Bath; but the steady uniform temperature of the latter no way accords with the uncertain tumultuary disturbance of the former. For any probable explanation we must have recourse to some invariable operation of nature; and it appears to me, from the following circumstances, that the temperature of every warm spring depends on the different depths below the surface of the earth through which the water has flowed.

It is by most philosophers believed that the earth is the grand repository of caloric; the higher we ascend, the colder we find it; and in these latitudes it accords nearly to  $1^{\circ}$  for every 300 feet of elevation. The irregularity of the earth's surface answers a very important purpose to the vegetable kingdom; from the varied temperature, different vegetables are enabled to pass with more energy through the periods of their

existence: thus, oaks flourish at the bottom of mountains, beech at the mean height, and pines at the top.

The aqueous part of our globe we are not to consider as being generally intermixed, and possessing the same properties. When we dig into the earth to a certain depth, water is found; if we dig still deeper, another spring appears, no way connected with the former; and, in digging in different parts near to each other, springs are opened, which in many instances pour forth water, each of different properties.\* Thus, in Cheshire, before they enter into their brine springs, they cut through many springs of fresh water. Those who have made observations on the different springs in the vicinity of Bath, have remarked the difference of water according to the stratum from whence it is evolved: thus, the springs from the coral brash at Woolverton, the Hinton springs from the forest marble, the springs of the great freestone at the Cottage-Crescent and Brass-Knocker; those from

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\* The circumstance of hot and cold springs rising near to each other, is noticed by Pliny. Vide No. 407 of the Philosophical Transactions. There is a curious remark relative to Buxton, that a hot and cold spring rose so near to each other, that the same person could immerse a hand into both at the same time, but now they are blended together. If such be a correct statement, the temperature of the Buxton warm spring might have been superior to Bath; at present it only possesses  $82^{\circ}$  of heat. A remarkable circumstance is recorded of one of the hot springs at Buda in Turkey,—rising in an open pond of cold water!

the bastard freestone at Claverton, the lyas at Weston, and the millstone at Newton,—these possess sensibly different properties, and a knowledge of their relative situations is in some instances of importance.

The hills about Bath mark the boundaries of many of the strata, one stratum dying gradually into another; so that the sides of the hills give a beautiful geological illustration of these earthly layers; and their respective dips or inclinations enable us to form a tolerable conjecture as to their thickness in any part of Bath. Thus, the water from the great freestone is by no means so pure as that which flows through the bastard species; for, as the latter lies under the former, if, in sinking a well, the spring should arise from the great freestone, it is generally so charged with calcareous matter, as to preclude its being used for domestic purposes; and if we stop the spring by puddling, and perforate the freestone to the next layer in order, a very fine water is generally procured.

The irregularities of the surface of the earth occasion those currents and streams of water which we observe. If our barometrical calculations are correct, it appears that the greatest depth of the wells at Schemnitz is 200 fathoms higher than the city of Vienna: this would give the direction to any water flowing on the surface of that part of the globe.

Although we are but little acquainted with the structure of the earth, our observations having hitherto been confined to very small depths below its surface, yet, as in these may be discovered a certain regularity of arrangement till we arrive at the granite, it has hence been supposed by some geologists that the granite constitutes the nucleus of our planet, and the basis of all our primary mountains.

In Cornwall, from Land's-End to near Plymouth, we remark the granite, in which substance tin alone is found; on the N.W. the killas or gneiss, extending up towards Devonshire, in the southern part of which county, viz. about Plymouth, is the marble limestone, whilst towards Barnstable it is quite an argillaceous schist, which gradually changes into an argillaceous loam between Linton and Bridgwater. A remarkable bed of clay extends from Lime to Bridgwater, so as to induce one to suspect that at some period it must have formed the bed of a river. Here the limestone of Somersetshire commences, and continues to the chalk of Wiltshire.\* To the miner it is of the highest importance to be well acquainted with these strata, it being by this knowledge that he is enabled to

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\* With respect to these strata, I am indebted to my friend, Mr. H. Wansey, who has favoured me with a geological map, the result of his own and of Dr. Maton's observations.

carry on his researches for different minerals: it would be absurd for any person to attempt to discover tin in Somersetshire, and equally unproductive to sink a shaft in Wiltshire, with the hopes of finding coal.

As these strata are serpentine in their course, all springs peculiar to them will follow the same direction, when determined over hills and descending into vallies. It is evident, from the law of fluids, that if an opening should be made in the descending part of the stratum, the water will rise nearly to a level equal to the highest part of its course; thus, in the shaft sunk at Batheaston for the purpose of procuring coal, my ingenious friend, Mr. W. Smith, informs me that, in perforating the white lyas at the depth of between four or five hundred feet, the spring cut into immediately ascended to an elevation of 360 feet.\*

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\* The water, when pumped up, is found to be at a temperature of about 52°; but its warmth at the bottom of the pit has not yet been ascertained. The steam-engine, employed for the removal of this water, has apparently an effect on the Cross Bath, the bed of which being the highest, would soonest be affected. The Cross Bath reservoir is observed to fluctuate in the time of filling, from 16 hours to 28; and this fluctuation, Mr. S. has remarked, coincides with the exhaustion of the Batheaston spring. Should this be the case, and should the Batheaston works be regularly employed, all the hot springs will suffer, and that in the order of their elevations, viz. the Cross Bath, the Hetling-court, the King's Bath, and lastly the Kingston, as being the lowest,

As, amongst the earths, clay is found to be the most retentive of water, if, on any of the strata containing springs there should be an argillaceous bed, any communication (natural or artificial) to the surface of this bed, the water will be retained. It is well known that an abundant spring is never found where there is a great depth of sand, without any stratum of clay to force it upwards, as in the sandy deserts of Arabia, and the immeasurable plains of Lybia; so, upon the same principle, we rarely have springs where the surface to a great depth consists of clay. In digging for wells, if we begin with sand or gravel, water is rarely found till we arrive at clay; and, in case of commencing with clay, we must cut through the bed to the sand or gravel, before we shall find a spring. Upon these principles draining and irrigation depend.\*

With respect to the Bath hot springs, we find them flowing on a bed of firm blue argillaceous marl, which is

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\* The resisting power of clay, as to water, was surprisingly illustrated by the circumstance of the Solway moss, which occurred November 16th, 1771:—The water which carried it off insinuated itself between the smooth bed of clay below the moss, in such great quantities, as to heave up the moss, and to float it in its natural state to a considerable distance, and deposited it on some corn-fields, to the extent of four or five hundred acres, which are now covered with several feet thickness of this moss, and has consequently caused a very serious injury to the proprietor of the land.

itself placed over the white lyas: this has given rise to a supposition that the springs may originate in the latter stratum; for, as the Bath Waters possess some properties which the white lyas, or any of the known strata which lie over it, do not possess, we may therefore presume that the warm springs are determined from a source still deeper.

This blue marl is not visible in any of the reservoirs, except that appertaining to the Kingston Baths. The beds of the other reservoirs have been raised by large quantities of alluvial matter, brought from the neighbouring districts; hence arise the nuts, and other extraneous matter, found upon cleansing the springs, but which substances are not determined there by the spring. When the alluvial matter is bored through, then the same argillaceous bed is discovered.

From the serpentine direction of these aqueous vessels, they descend more or less below the surface of the earth; and the deeper they go, the warmer they will be, from the temperature of the earth increasing in proportion as we descend; but we have not experiments enow to enable us to determine the ratio of increase.

The earth, near its surface, is gradually heated during summer, and cooled during winter; at greater depths it becomes less influenced by changes of season, until ultimately the temperature remains unchanged in the same

places. As we descend, the warmth increases; and hence we may suppose that, at depths of some miles, the temperature would be found superior to any degree of heat with which we may be acquainted.

From the oblate spheröidical form of the earth, we have reason to believe that at some period it was a fluid mass; and, as it assumed the solid character, the form now observed would be such as must necessarily arise from the diurnal motion. Those mountains, which constitute, among geologists, the primary range, (in which no organic remains have been observed, and hence supposed to be coeval with the solidification of our planet) appear from some circumstances to constitute the superior part of a vascular ramification; and, in proportion to their elevation, they give rise to extensive lakes and rivers. Thus, the lakes in Cumberland and Westmoreland are formed by the surrounding mountains, which are primary bounded by secondary; the Po in Italy arises from the Piedmontese mountains; the Rhine and the Rhone, from those in Switzerland; and the Garonne, from the Pyrennées. When the mountains are more extensive in their range, the lakes and rivers are proportionately greater, as the river Senegal, for instance, which has its source from the mountains of the Moon, and the extensive La Plata from the Andes.

From what source are these mountains supplied with that astonishing quantity of water determined from them? Probably, the tops of the most elevated mountains, as the Andes, do not exceed the mean distance from the centre of the earth of that portion, under a corresponding latitude; if so, the motion of the earth round its axis would be sufficient to explain the cause: whether such be the case can only be admitted as conjectural.

The cave of the observatory at Paris is 90 feet below the level of the street. Its temperature remains so uniformly at  $53^{\circ}$ , that, prior to Fahrenheit's scale, it was adopted as a graduating point. In all dry situations, at similar depths below the earth's surface, the same regular warmth is observed. Thus, in Nottingham, which is founded upon a rock, dry cellars are made, of such depths that there is no variation of temperature. This circumstance occasions the process of malt fermentation to be so completely carried on, as to have rendered that town truly celebrated for its ale. In other situations, the temperature will be so influenced by local circumstances, as to prevent any general rule with regard to the increase of temperature, in proportion to the descent being ascertained. If a stratum retain a considerable portion of humidity, the evaporation from the damp surface will abstract a certain portion of caloric: to this

cause we may attribute the comparatively small increase of temperature at different depths in some places. Thus, in the salt-mines at Wilickza in Poland, which are from 300 to 716 feet deep, the temperature is uniformly  $52^{\circ}$ ; at Boulogne, in a mine 476 feet deep, the heat is at  $54^{\circ}$ . When De Luc examined the copper-mine at Hartz, at the depth of 1359 feet, the thermometer rose as high as  $70^{\circ}$ . A most remarkable circumstance is mentioned by Van Swinden:—A friend of his had a pit dug within the polar circle, with a view of ascertaining any change of temperature; at 24 feet deep the earth was hard and frozen, lower than this it became soft, and at 40 feet the water was not only fluid, but even raised the thermometer as high as  $54^{\circ}$  or  $56^{\circ}$ .

These are but trivial depths to what we may rationally suppose some springs descend, from the inclination of the strata, as may be remarked in elevated districts; for springs, following the direction of these strata, in many instances, probably descend as far below the surface as they are elevated above it.

It is evident that the spring will acquire a temperature corresponding to the stratum through which it passes; and, according as it is sooner or later determined to the surface of the earth, so the warmth of the spring will be regulated. Thus, the springs at Rykum and

Geyser in Iceland, a gentleman who lately visited them informs me, after rising to the height of 60 or 70 feet, on the descent of the water, its temperature in that cold latitude is equal to boiling water of 211 or 212°. If this be the case, after passing through such a mass of cold air, the temperature of the water just prior to its emanation must be very great.

The celebrated Klaproth, in his masterly analysis of the hot springs at Carlsbad, remarks, that “the decomposition of pyritical matter could not produce that quantity of caloric which, for so many centuries, has preserved these waters at the same uniform temperature:” he attributes it to a “subterraneous store of mineral coal, that remainder of the vegetable world, locked up in the bosom of the earth.” Although a subterraneous store of coal occurs in various places in strata of an enormous thickness, we are not acquainted with any such masses in a state of combustion, unless where there exists some aerial communication, as is the case near Bewdley, an inflammation of carbonaceous matter extending over nearly twenty acres of ground, and visible in the night; although at Carlsbad the earthy scorixæ observed in the neighbourhood might justify some such supposition, as might the hot springs at Bath, which are surrounded by coal strata: but the boiling springs of Iceland are surrounded by granite, where mineral coal cannot be suspected. Attri-

buting the warmth to the depth to which the spring descends, is ascribing it to a cause which must remain invariably the same as long as the same structure in that part of the earth continues. To vary this temperature would be to alter the direction of the strata, and which could only be effected by some tumultuary operations of nature. There are some instances, where every mineral water may be altered in its character by the intermixture of water from contiguous springs; this has already been remarked in the case of the Buxton waters; and to a similar infiltration of cold water is to be attributed the diminished temperature, and the less proportion of saline matter, in the waters at the Cross Bath than in the others. Upon repairing this bath about twenty-five years since, the cold springs were attempted to be separated from the warm ones by a stone wall, through which they soon percolate; and as the Cross Bath has been lately trenched round, and puddled with clay, all the springs are locked up together, which necessarily occasions the water to be colder, and the saline contents in a given quantity to be less.

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### CHAP. III.

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## ON THE SENSIBLE PROPERTIES OF THE BATH WATERS.

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**T**HE water, when fresh pumped, appears clear and transparent; but, if retained some time in the glass, it assumes a muddy appearance, and makes a slight ferruginous deposit. This deposition is accelerated by placing the water under an exhausted receiver: the air, which is given out by boiling the water, differs only from the air disseminated through common spring-water, by containing a larger proportion of carbonic acid gas: during the boiling the ferruginous deposition is increased.

When the water is drank immediately from the pump, there is a very slight chalybeate taste: in this respect there is no sensible difference in any of the hot springs, except those of the Cross Bath, necessarily arising from

the causes before mentioned. This metallic taste undergoes no change at any period of pumping, unless the water is allowed to remain in the pump-barrel, or suction-pipe, until its temperature is lower than  $100^{\circ}$ . The reason of this will be hereafter explained.

The disposition of the Bath Waters to retain caloric differs very little from common water. Two equal-sized glass vessels were filled, the one with Bath water, and the other with common water; thermometers were introduced into each, and the proportion of cooling observed when both were at the temperature of  $110^{\circ}$ : at the diminution of  $10^{\circ}$  of temperature in the spring-water, the Bath water was reduced  $9\frac{1}{2}^{\circ}$ ; in the next  $10^{\circ}$  the difference was less. Upon reversing the experiment, in order to guard against any error arising from the thermometers employed, or the different capacities for caloric in the vessels holding the water, the same proportion appeared. To this experiment I paid particular attention, as the result controverted some experiments I had formerly made, from which I had deduced, that this water, naturally heated, in its retentive power for caloric, exceeded that of common spring-water artificially warmed. It is not easy to procure two thermometers, whose play in the range of temperature shall so exactly coincide, that the mercury in each shall be correspondingly expanded by the same increments of heat,

that the difference of a fraction of a degree cannot at all times be depended upon.

Into two equal-sized glasses the same measure of spring-water, at the temperature of  $54^{\circ}$ , was introduced into each; a corresponding measure of Bath water at  $108^{\circ}$  was poured into one glass, and the same measure of common water, raised to the same temperature, mixed with the water in the other glass; the temperature of each admixture was between  $79$  and  $80^{\circ}$ .

From this experiment, it appears that there is no sensible difference in the capacities for heat either in spring-water or Bath water, which was additionally illustrated by the following experiment:—

Two equal-sized tin canisters were filled, the one with Bath water at  $110^{\circ}$ , and the other with spring-water at the same heat. These were immersed in two glass vessels, filled with water, of the same dimensions, the temperature of the surrounding water being at  $54^{\circ}$ : the increase of warmth was marked every quarter of an hour, no sensible difference was observed.

Four ounces of Bath water, and the same quantity of spring-water, in separate glasses, each at the temperature of  $110^{\circ}$ , were mixed with one ounce of the muriate of ammonia, and the same quantity of the nitrate of potash: a diminution of temperature of  $35^{\circ}$  was produced in each portion of water.

From these circumstances we may reasonably deduce, that the retentive powers of the Bath water for caloric by no means differ from common water.

Mr. Phillips, in his very ingenious and elegant analysis of the Bath Waters, observes, that after the water has been preserved at rest, and exposed to the air, a white precipitation takes place. In every instance, where I have observed the deposition, it is of a yellowish colour, arising from the intermixture of the carbonates of iron and lime: in the private baths this yellow tinge is very perceptible, and gives it very much the appearance of sea-water.\* The Kingston Baths are lined with Dutch tiles, and upon these the colour of the deposit is easily determined; and the incrustation is sometimes so firm, as to require the assistance of a chisel to detach it.

In every spring-water, the quantum of carbonic acid gas is always in greater proportion than the other constituent parts of the atmosphere: it appears, from the experiments of Mr. Dalton, that water will absorb its own bulk of carbonic acid gas,  $\frac{1}{27}$  of oxygen gas, and  $\frac{1}{64}$  of nitrogen gas; on this account, when a confined mass of atmospheric air is exposed to fresh distilled water,

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\* Sea-water, when examined in a glass, has a yellow tinge, the greenish hue it presents arising from the intermixture of the reflected blue rays from the sky: the more unclouded the weather, the deeper is the greenish tinge.

there is not only a diminution in quantity, but also a deterioration as to purity, and the residual aërial mass will be found to contain a less proportion of pure air. Under the pressure of our atmosphere, water at the temperature of  $50^{\circ}$  will absorb its own bulk of carbonic acid gas; not arising from the capacity of water at a diminished temperature being increased for such an absorption, this remains invariably the same, but from the elasticity of a gaseous fluid being in the ratio of its sensible temperature. Thus water at the temperature of  $100^{\circ}$ , exposed only to atmospheric pressure, will retain a very small portion of any gaseous principle. When the surrounding pressure is increased, the quantum of air mechanically diffused through water is proportionally augmented. At the orifice by which the Bath Waters emanate, a considerable quantity of air is at the same time evolved, which is found to consist of oxygen, nitrogen, and carbonic acid gases; but none of these can be traced in the waters in an uncombined state. The carbonic acid gas, which is given out by boiling the water, previously existed in combination with the carbonates of iron and of lime; but these are precipitated, as the boiling process is continued. Upon exposing to lime-water 100 measures of this air, four measures were absorbed, and the usual cloudy appearance produced: the same diminution occurred upon exposure to barytic water, and to a solution of pure potash.

The residual gas was exposed to a solution of the green muriate of iron saturated with the nitric oxide, according to Mr. Davy's plan, and an absorption of nearly two measures took place. As the sulphate of iron contains iron in its minimum state of oxygenation, forming a very soluble salt, when exposed to any oxygen, a combination takes place, and a brown oxide of iron is formed; the residual air being introduced into a phial, with a solution of the green sulphate of iron in distilled water, frequently agitated, the discolouration in a few hours became very distinct.

The remaining and the greatest portions of the gas being ascertained by its incapability of inflammation, by being inodorous, and by giving no tinge to metallic solutions, to be neither hydrogen or either of its combinations with carbon or sulphur; and, as what carbonic acid and oxygen gas previously intermixed with it had been removed, it was concluded to be nitrogen, as we have no direct test for this gas. This was determined by the celebrated experiment of the Honourable Mr. Cavendish, by the passage of electricity through one measure of this gas, and  $2\frac{1}{2}$  measures of oxygen, introduced into a glass tube along with a solution of pure potash. The interrupted spark from a two-feet plate machine was passed for one hour, the gases introduced were very considerably diminished, and the nitrate of

potash was formed: when the salt was dried, the deflagration was very distinct; and the crystals, when examined through a microscope, had the usual needle-formed arrangement.

From these experiments we may deduce, that the air evolved at the spring consists of 94 parts of nitrogen gas, 2 parts of oxygen, and 4 parts of carbonic acid.

Dr. Priestly was the first who ascertained the existence of nitrogen gas in the Bath springs. This great proportion of nitrogen gas has led to a supposition, that there exists some animal matter, as marine exuviae, continually decomposing in the strata through which the hot water is determined. The strata which are exposed to our view only evince these materials in a fossilized state; and, for the disengagement of nitrogen gas, it is necessary that a considerable proportion of animal matter should be present. Mr. Hatchett, in his valuable analysis of bones and shells, remarks, that the fossil bones found in the rock of Gibraltar consist of the phosphate of lime, without any cartilage, or soft animal matter, the interstices being filled with the carbonate of lime; whilst a human bone, *os humeri*, brought from Hythe in Kent, and said to have been taken from a Saxon tomb, after immersion in muriatic acid, afforded a cartilaginous residuum nearly as complete as in a recent bone.

From whatever source this may arise, it is of no great importance in a medical point of view, as none of it is retained by the water at the period when taken internally; although it has been imagined by some, that to this may be attributed the giddiness frequently induced by drinking the Bath water, comparing the effects to those produced by the nitrous oxyd of Mr. Davy.

There is a material difference between nitrogen and its combination with oxygen to form the gaseous oxyd: the peculiar effect of the latter on the nervous system arises from its being introduced into the lungs, whilst the former is only taken into the stomach. What is injurious to one viscus may be beneficially stimulant to another: this is strongly illustrated by the effects of carbonic acid gas, which is remarkably pernicious to the lungs, and as grateful to the stomach.

Nitrogen gas has been detected in the Buxton waters by Dr. Pearson, in the Harrowgate by Dr. Garnet, and in the Lymington waters by Dr. Lambe. In all these waters it exists in such minute proportions, that no medicinal effect can be ascribed to its presence. Dr. Fothergill maintains its existence in the Cheltenham waters, but that does not seem to be the case in Mr. Accum's analysis.

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## CHAP. IV.

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# ON THE EXAMINATION OF THE BATH WATERS BY TESTS AND RE-AGENTS.

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**W**HEN we wish to ascertain the existence of a substance, by means of an article in which no chemical change in its properties is effected, this is denominated a test. Such are the different vegetable infusions, as litmus, violets, turmeric, Brazil wood, red cabbage, &c. employed for the ascertainment of acids and alkalies; yet we do not observe that the alkalescent or acid properties, by such admixtures, are at all altered.

By a re-agent we are to understand that substance which is employed to break the bond of union existing in any compound, and to form with one of its parts another chemical arrangement. Thus lime, in any of its combinations with sulphuric, nitric, muriatic, and carbonic acids, is detached by the oxalic acid by the simple law of affinity, and becomes perceptible by forming with it an insoluble compound. In many instances a compound re-agent is necessary to be employed; thus, the prussic acid would not detach iron from many of its

combinations, which the prussiates of potash or of ammonia would readily effect: so, also, pure ammonia will precipitate the magnesian salts, but not lime; whilst the carbonated ammonia, by the double law of affinity, will decompose all the earthy salts. Thus, alkohol will not dissolve the carbonates, the muriates, or the sulphates of potash or soda; but it will dissolve the pure alkalies and the earthy muriates: but alkohol cannot with propriety be denominated a re-agent, though it is of very great importance in chemical analyses, from no sensible change being induced in the substances which it holds in solution.\*

When a substance is already in a state of combination, it will not be entirely detached by the agency of another to which it has a greater affinity; but it will be divided in the ratio of their respective affinities. This important law, for the knowledge of which we are indebted to the celebrated Berthollet, points out the necessity in many instances of employing a re-agent to a state of excess. Thus, potash will take part of the acid from the sulphate

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\* Fourcroy observes, that alkalies appear to decompose spirit of wine: although in the first distillation pure alkohol is given out, yet a thickish substance remains, which, on the application of a greater heat, yields spirit of wine, volatile alkaline spirit, and a light empyreumatic oil. It is not a very easy matter to procure good alkohol: the mode I adopted in the alkohol used in these experiments was, by adding to each pint of rectified spirit two ounces of the carbonate of potash, and slowly distilling it, reserving only the first eight ounces for my experiments.

of barytes, or the oxalate of lime, whilst in other cases we must be guarded in not employing them to excess; for, although the oxalic acid forms with lime an insoluble compound, which, when dried, enables us to appreciate the quantum of lime, if the acid be in a state of excess, it will dissolve the new-formed oxalate, and lead to an error in the analysis. In such instances we employ the acids in a state of combination: thus, the oxalate of ammonia possesses the double affinity, whilst the excess of oxalic acid being neutralized, will not hold in solution the precipitated oxalate.

In all my experiments by tests and re-agents, it is to be understood that equal-sized test-tubes were employed, and the comparative experiment made with distilled water.

Into some Bath water, fresh pumped from the spring, some tincture of litmus was introduced, with a view of detecting any carbonic acid uncombined; but, after six hours, no difference of colour from litmus and distilled water could be perceived.

Lime-water was agitated with a portion of Bath water, but no turbidness induced. As the tincture of litmus remained unchanged, it was a proof of there being no uncombined acid. So also a tincture of red cabbage, *brassica rubra*, produced no effect.

The acetat of lead produced a white precipitation; this occurs with the sulphates of lime or of potash, and

in a very sensible degree with carbonic acid gas: as the latter was proved by the previous experiments not to exist, it demonstrated the existence of some salts with sulphuric acid. This was additionally confirmed by the white precipitation occasioned by the nitrate of barytes; when dried it was insoluble in nitric acid, and consequently was the sulphate of barytes.

Pure ammonia was added to some Bath water, and a cloudy precipitation took place. As this precipitate might be either lime, magnesia, or ammonia, when dried, sulphuric acid was poured upon it, which evaporated gently to dryness; then one hundred times its weight of distilled water was poured upon it, and no solution took place—a proof of its being neither magnesia or alumina, as with either of those it would have formed a soluble salt.\*

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\* With regard to pure ammonia, no dependance can be placed upon what is procured from the druggists; for, from its occasional exposure to the air, it readily absorbs carbonic acid, and thus becomes capable of decomposing calcareous salts. Even when perfectly pure, and no change induced in a mineral water holding sulphate of lime in solution, yet if the bottle be only partially filled, or the contents exposed to the atmosphere, a turbidness will take place, and lead to the suspicion of magnesia or alumina. It is always advisable to introduce some ammonia into a small retort, to apply a gentle heat, and to let the ammoniacal gas pass into the bottle of water to be examined, for the carbonated ammonia will not be detached by so small a heat. If there should be no carbonate of lime, and a turbidness quickly produced, it is magnesia; if the change be very slow, it is alumina.

The oxalic acid and the oxalate of ammonia produced a similar coloured precipitation, evincing the existence of lime in some state of combination. A solution of the carbonate of ammonia produced the like effect, which occasions no precipitation of either the carbonate of alumina or of magnesia. Distilled water, impregnated with sulphuretted hydrogen, produces only a slight cloudiness; as iron is the only metal suspected in mineral waters, and this is not precipitated by liquid sulphuretted hydrogen, but is thrown down in a blackish state by the hydrosulphuret of potash; however no such effect was produced in the Bath Waters, consequently no metallic oxyd is contained in them.

The prussiate of ammonia produced no sensible change; the greenish yellow tinge, which after some days appears, arises from the carbonate of lime; the prussiate of potash and iron produced the same appearances.\* This change had been observed by Mr. Phillips. Tincture of galls, prepared after Scheele's plan, has a very slight shade of difference from distilled water, and, after stand-

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\* As all the prussiates contain iron, it is not very easy to ascertain the portion of iron existing in any compound, since we do not know the precise quantity any prussiate employed previously contains. Proust says that the prussic acid forms, with iron combined with its least dose of oxygen, a white prussiate, and with its greatest dose, a blue prussiate; in the Bath Waters no sensible change takes place.

ing two days, makes a very minute precipitation. Into a gallon of water, boiled down to a pint and filtered, some tincture of galls was added, but without any sensible discolouration. The discolouration effected in the first experiment by the gallic acid disappeared on boiling the mixture.

The mild nitrate of mercury and nitrate of silver, prepared without heat, produced a cloudy precipitation, which, when collected and dried, was found insoluble in nitric acid.

From these circumstances we may deduce, that there exist in the Bath Waters the carbonates of lime and of iron, and combinations with sulphuric and muriatic acid. The experiments evince that there is no magnesia or alumina; but no re-agent or test will ascertain the existence of silica whilst in a state of solution. To ascertain the proportion of the constituent parts, and whether the combinations with the sulphuric and muriatic acids were lime, soda, or potash, it was necessary to evaporate a large quantity, in order to proportionately diminish any errors with respect to the solid contents.

I filled a copper, which being found, as usual, similar to the frustrum of a cone, the diameter of the smaller end being 26 inches, the larger 30, and the depth 25 inches; hence its capacity was nearly as follows:—

The mean diameter is .....  $\frac{30 + 26}{2} = 26^{\circ}$ —

$26 \times 26 \times .7854 \times 25 = 13194.72$  cubic inches. As  
 28.875 cubic inches correspond to the capacity of a pint,  
 we shall find that  $\frac{13194.72}{28.875} = 557$  pints. By a slow

evaporation, never amounting to boiling, as it is well known that many combinations with muriatic acid become decomposed at a very low temperature; when reduced to about five quarts, it was removed into a copper saucepan, and exposed to a sand-heat till more than one half was evaporated; afterwards it was poured into a common soup-plate, and gently evaporated to dryness. The solid matter weighed 11 oz. 4 dr. 36 grs. the salt was much discoloured, and of a dirty appearance. From hence it appears, that each pint of the Bath water holds in solution 9.97 grains of saline matter.

I evaporated in a similar manner six gallons of the King's Bath, Hetling-court, and Cross Bath waters, when a similar discoloured sediment took place. The King's Bath gave 433.5 grains; the Hetling-court, from the common pump in the street, gave 447. grains; and the Cross Bath, 318.7 grains.

The proportion of each spring is as follows:

Kingston Bath contains 9.97 grains in each pint.  
 Kings's Bath ..... 9.03 ditto

Hetling-court..... 9.40 grains in each pint

Cross Bath ..... 6.6. ditto

The quantum of solid matter in the three first springs, I am persuaded, under the same conditions, would have as nearly corresponded as the nature of such experiments will admit. It is impossible, with the greatest degree of care, to prevent a certain portion being attached to the vessel in which the evaporation has been conducted; and it is evident that the larger the quantity of water evaporated, the less in the division will be lost. If we suppose one dram lost by this circumstance, when the quantity of saline matter amounts to more than 90 drams, the loss would only be  $\frac{1}{90}$ ; and in the other instances, where only the solid matter formed by the evaporation amounts to little more than 7 drams, the proportionate loss would be  $\frac{1}{7}$  or 13 times more. The water from the King's Bath I had from the open reservoir: this may in some respects account for any apparent difference between the King's Bath spring and the Hetling-court spring. The Queen's Bath has no independent spring, but merely a reservoir supplied from the King's Bath. The diminished quantity of saline matter in the Cross Bath appears to depend on the circumstances before stated, viz. an intermixture of fresh-water springs with the warm stream: by this dilution, the solid contents must be proportionately diminished. That

such is the case, will be rendered more probable by the analytical statement.

In comparing the results of the different analyses which have been made of the Bath Waters, there is a considerable difference in the statement of the saline contents. The examinations made by others have been confined to the King's Bath water; but observations as to the properties of the other springs have arisen from conjectures, unsupported by any chemical investigation, in general deemed unnecessary, from its being believed by most medical men of eminence, that any difference as to the properties of the springs is merely ideal. From the results of the present analysis, and the analyses conducted by former gentlemen, the following table of the properties of saline matter is formed:

Kingston Bath.....	$\frac{1}{735}$
Hetling-court .....	$\frac{1}{775}$
King's Bath .....	$\frac{1}{806}$
Cross Bath .....	$\frac{1}{1100}$
Dr. Lucas .....	$\frac{1}{435}$
Dr. Charlton .....	$\frac{1}{425}$
Dr. Falconer .....	$\frac{1}{821}$
Dr. Gibbes .....	$\frac{1}{627}$
Mr. Phillips .....	$\frac{1}{490}$

This difference may in some respects depend on the different degrees of dryness of the saline contents. In

my experiments they were exposed in a Wedgwood evaporating-dish to a sand-heat for three successive days, the heat never exceeding 180 degrees, and was thus weighed. It appears that the same circumstances were attended to both by Dr. Falconer and Dr. Gibbes, from the near coincidence as to the solid matter. Mr. Phillips, whose chemical talents are well known, appears to have conducted his very ingenious analysis on too small a scale; a trivial error under such circumstances would become evanescent when a great quantity of water is employed.

As water does not proportionately increase in bulk by holding in solution saline matter, upon the principles of the laws of specific gravity, Mr. Kirwan has laid down a formula for estimating the saline contents of any mineral water. According to Dr. Falconer and Mr. Phillips, the specific gravity of the Bath water is 1002, supposing the specific gravity of distilled water to be 1000. The following theorem is deduced from experiments:— $\frac{1002-1000}{2.8} \times 1.4 = 2.8$  the saline contents in a thousand parts of the water in question. This gives a proportion greater than what appears from the above statement, viz.  $\frac{1000}{2.8} = 392$ . Hence,  $\frac{1}{392}$  will express the quantity of saline matter. We are not informed whether the salt is thus expressed as in its dryest state, or if in the ascertainment of the specific gravity there

should be an error of  $\frac{1}{2000}$  part of the weight, the difference would be accounted for.

As Mr. Kirwan had ascertained by experiment that when the specific gravity of a mineral water exceeded the specific gravity of distilled by  $\frac{1}{1000}$  part, that the saline contents bears the proportions of  $\frac{1.4}{1000} = \frac{1}{785}$ , from whence his formula has been deduced; but Dr. Falconer found the specific gravity of common pump-water to be 1.0016. As this water in Bath is charged with the carbonate and sulphate of lime, we shall find it to be near the proportion of its saturated quantity. That water will dissolve, in its usual state,  $\frac{1.0016 - 1000}{1000} \times 1.4 = 2.24$ ; if we subtract this quantity from the estimate of the saline contents of the Bath Waters, we shall find that the difference between the latter and common pump-water, independent of their iron and temperature, exists only in the alkaline muriates and sulphates; and we shall find that  $\frac{2.8 - 2.24}{1000} = \frac{1}{1787}$ , which will be found very nearly to correspond with the proportion of the muriate and sulphate of soda existing in the Bath Waters. Dr. Falconer has remarked, that the gross contents of the Cross Bath are  $\frac{1}{10}$  greater than the saline contents of the Hot Bath, and near  $\frac{1}{5}$  greater than the solid matter of the King's Bath. From the results of my experiments I find the Cross Bath does not leave so much saline residuum after evaporation as either of the others. In the table relative

to the number of grains, that a pint of the different waters exceeds the same measure of distilled water; Dr. F. remarks that a pint of the King's Bath and Hot Bath waters exceed by 26 grains, and of the Cross Bath by 24.1 grains the same measure of distilled water; whilst it would appear that the reverse should be the case.

As one pint (wine measure) of water weighs 7310 grains, and one pint of the Hot Bath water weighs 7310 + 26, then the specific gravity should be 10035; for  $7310 : 7310 + 26 :: 1000 : 1003.5$ .

I have been particular in my remarks on these experiments, from knowing Dr. Falconer's great ability in conducting investigations of this nature, and with a view of evincing the great difficulty in making all our estimates consonant with each other. It is on this account that I submit the results of my experiments with the utmost diffidence to the public; and though they have been conducted with all the attention in my power, yet I am well aware that many circumstances may have escaped me, which may probably be developed by a future analyzer.

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CHAP. V.

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ON THE PROPORTIONATE CONSTITUENT  
PARTS OF THE GROSS CONTENTS  
OF THE BATH WATERS.

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**B**Y the tests and re-agents which have been employed, it has been ascertained that there exists in the Bath Waters, lime in combination with carbonic acid and sulphuric acid, a minute portion of iron, and the sulphate and muriate of soda or potash. The last alkali is very rarely found existing in any state of combination in a mineral water; we have only one instance on record, in Crell's Chemical Annals of the Waters of Uhleaborg, and that in so small a proportion as not to exceed  $\frac{1}{40.000}$  part of the water analysed. In the analysis here alluded to, the existence of this alkali is by no means satisfactorily proved; nor was the excellent re-agent, of which we are at present in possession, then known, by which soda is distinguished from potash, the principal

dependence being upon the deliquescent or efflorescent appearance of the salt. All combinations with potash are disposed to absorb moisture from the atmosphere, whilst all chemical arrangements with soda have the reverse disposition. When the proportion is very small, as in the above instance, it is not by these circumstances easily ascertainable. The very ingenious Dr. Marcet has shewn, that fresh-made muriate of platina will precipitate soda, but not potash; and we shall see by the analysis that there is no potash in the Bath Waters.

Four hundred grains of the well-dried salt, and six ounces of distilled water, were put into a matrass, and gently simmered for two hours: when cool, the solution was filtered; and the residual matter, and the filter on which it was left, being gently dried, weighed\* 257 grains. The solution was slowly evaporated to one ounce, when a slight precipitation was observed, which, on being filtered, weighed four grains; so that the earthy compounds, with the silex and carbonate of iron, weighed 261 grains. To the solution were added three ounces more of distilled water, in order to render the subsequent

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\* To guard against any error in weighing, two equal-sized filtering-papers were cut, and both gently dried; and the one not employed was placed in the opposite scale, as a balance for the filtering-paper used.

precipitations more distinct. Two drams of this solution were tried in a test-tube by sulphuric acid, but no turbidness appeared—a proof of there being no combination of lime with muriatic acid. A very slight degree of cloudiness occurred from the oxalate of potash, arising from a minute portion of the sulphate of lime held in solution.

Klaproth observes, that 100 grains of common salt dissolved in water, and dried in the air, when decomposed by a nitric solution of silver, yields  $233\frac{1}{2}$  grains of dried muriate of silver.

Sulphate of lime, dried at  $170^{\circ}$ , being nearly the heat to which it was exposed in this experiment, according to Kirwan, consists of 50.39 acid, 35.23 lime, and 14.38 water of crystallization: and sulphate of barytes has been ascertained by Klaproth to consist of 67 parts of barytes and 33 of sulphuric acid; so that 100 grains of gypsum, liberated from so much of its water of crystallization as the sand-heat temperature of  $180^{\circ}$  would effect, will be equal to 151.5 grains of the sulphate of barytes.

Klaproth, in his valuable analysis of the Carlsbad waters, observes, that 168 grains of dried sulphate of barytes is equal to 100 grains of dried sulphate of soda, or Glauber's salts.

To the solution was added dissolved acetat of barytes,\* as long as any precipitation took place; which, when filtered, and well dried, weighed  $75\frac{1}{2}$  grains. From the above estimate of Kláproth, the quantum of sulphate of soda is 45 grains for  $168 : 100 :: 75.5 : 44.94$ .

To the filtered solution nitrate of silver was added, as long as any precipitation occurred; which, when filtered and dried, weighed 196 grains, very nearly equal to 84 of muriate of soda. According to the afore-stated proportion,  $233.5 : 100 :: 196 : 83.9$ .

The solution, now containing the acetat and nitrate of soda, was evaporated to dryness, and half its weight of sulphuric acid added, the whole being in a glass evaporating-dish, and exposed to a strong lamp heat, as long as any smell of acid continued; the dried salt was covered with water, and gently simmered till the whole was dissolved. Had the alkali been potash instead of soda, a salt would have been formed, which would have required five times more water than its own weight, even at the boiling point, to have dissolved it.

To this solution three ounces of water were added, and divided into two equal parts; one part was evaporated

\* In this case the acetat of barytes is employed in preference to the muriate, as by the subsequent experiment with the nitrate of silver an error in the estimate of the muriate of soda would have ensued.

to dryness and weighed, after which two ounces of alkohol were poured upon it, and it was then gently boiled. When cool, it was poured off clear, and the residuum being dried, was found to be exactly the same weight as before. So insoluble is the sulphate of soda in alkohol, that even at the temperature of  $100^{\circ}$ , if mixed with 70 parts of water, no solution will take place. The dried sulphate of soda was dissolved in one ounce of water; on this was poured the decanted alkohol, and the sulphate of soda was completely crystallized; to the other half was added the muriate of barytes as long as any precipitation continued, which, when dried, weighed 143 grains.

As the sulphate of soda, in its crystallized state, consists, according to Kirwán, of 23.52 acid, 18.48 soda, and 58 water of crystallization, I found the sand-heat temperature of  $180^{\circ}$  reduced 400 grains of the sulphate of soda to 228 grains; to drive off the last portion of water requires as much heat as would decompose the sulphate of soda. The diminution of weight in this case may be attributed to the water of crystallization: hence it is easily estimated, that the proportionate part in this desiccated state of the salt will consist of 41.3 acid, 26.3 water of crystallization, and 32.4 of soda. Upon the same principles, I found that muriate of soda consists of 41 acid, 55 soda, and 4 water.

The muriate of soda in the Bath Waters has been estimated at 84 grains = 46 of soda, and the sulphate of soda at 45 =  $14\frac{1}{2}$  grs. of soda; consequently,  $60\frac{1}{2}$  grains of soda will form, when dried at the temperature of  $180^{\circ}$ , 186 grains of the sulphate of soda; therefore 93 grains exist in each portion of the solution, it having been divided into two equal portions. As Klaproth has remarked, that 168 grains of the sulphate of barytes, dried at  $170^{\circ}$  = to 100 of similarly dried sulphate of soda— $168 : 100 :: 143 : 85$ —a deficiency of 8 grains; but it is a coincidence as near as the nature of these experiments will admit.

The muriate of soda remaining in the solution was crystallized, and examined by a glass, and the cubic form well marked.

To detach from the insoluble residuum of the gross contents the carbonate of lime and of iron, some muriatic acid, double the weight of the residuum, was poured thereon, and gently simmered to dryness; 4 ounces of distilled water were mixed with it, and boiled for an hour, which, when cool, was filtered, and the substance left on the filter weighed 236 grains, dried at the temperature afore-mentioned, consisting of the sulphate of lime and of silex. To the filtered solution the prussiate of potash was added, whereupon a blue flocculent appearance was immediately produced; but as it requires some days to

elapse before a solid precipitate is formed, it was therefore left for a week; and the prussiate, when gently dried, weighed 11 grains. As the prussiate of iron is estimated to consist of equal parts of the prussic acid and of iron in a state of oxyde, this would indicate  $5\frac{1}{2}$  grains of this oxyde. According to Proust, Prussian blue consists of a combination of the acid with the iron in its perox-yde, or in its maximum state; and in this state the oxyde contains 48 per cent. oxygen. The prussiate of potash is a triple salt, iron existing in it as one of its constituent parts; and it has been proved by Wiegleb, Westrum, and others, that, when deprived of this portion of iron, the property of the acid, in forming the Prussian blue, is destroyed. In an analysis, it is necessary to appreciate the quantity of iron existing in this compound, in order to guard against any error in the statement; for if there exist in a mineral water, at any period during the examination, any uncombined acid, a bluish tinge will be induced, so as to lead to a suspicion of iron existing in the mineral water. To estimate what allowance ought to be made on this account, I dissolved in muriatic acid  $5\frac{1}{2}$  grains of the red oxyde of iron, made by exposing the green sulphate of iron to a long-continued heat, and evaporated gently to dryness: this oxymuriate of iron was dissolved in distilled water, and precipitated by the prussiate of potash, which was collected and dried as before,

and weighed  $13\frac{1}{2}$  grains, being  $2\frac{1}{2}$  grains in excess; and, consequently, the carbonate of iron existing in the above proportion of salt cannot be estimated at more than  $4\frac{1}{4}$  grains. As the carbonate consists of 24 per cent. acid, the quantity of carbonate of iron will be 5.65 grains, or rather more than  $5\frac{1}{2}$  grains in 400 grains of the Bath salt.

To the solution, freed from the prussiate of iron, the carbonate of ammonia was slowly added as long as any cloudiness continued; the precipitate was dried, and weighed 22 grains, being the carbonate of lime. On this carbonate sulphuric acid was poured, evaporated to dryness, and weighed; this sulphate was boiled in four ounces of distilled water for one hour, filtered, and dried, without any loss of weight,—an additional proof of there being neither alumina or magnesia in the Bath Waters.

The residuum was then to be examined, which remained after the muriatic acid had been poured upon it, and which apparently consists of the sulphate of lime and of silex. To ascertain the exact proportion, this residuum was boiled with six times its weight of the carbonate of soda, in order to render the decomposition as complete as possible, to which were added four ounces of distilled water: this was filtered, and on the dry residuum was poured double the weight of muriatic acid, and simmered to dryness; and to this three ounces of distilled water were added, and boiled for some time. When fil-

tered and dried, the residuum weighed 11 grains; whereupon some more carbonate of soda was added, and boiled as before, and on the dried residuum some nitro-muriatic acid was affused, and boiled to dryness; distilled water was then added, and the dried residuum weighed 5 grains, which proved to be silex.

To Dr. Gibbes we are indebted for first pointing out the existence of silex in the Bath Waters. The very great difference between Dr. G.'s and my results may originate from the following circumstances:—Dr. G. in his very ingenious treatise, observes, that “on the residuum left after the evaporation of 168 ounces of the King’s Bath water nearly to dryness, he poured a considerable quantity of nitric acid, and left it to stand for above an hour; he then added a large quantity of boiling water, from which a white precipitate fell rapidly to the bottom of the vessel; and this precipitate, when carefully examined, weighed 20 grains. The oxalic acid did not decompose it, nor was its quantity diminished by being boiled a considerable time in distilled water.”

I am induced to suppose that the residual portion, thus examined by Dr. G. consisted principally of sulphate of lime or gypsum; had this been decomposed by a carbonated alkali, before the affusion of any of the acids, such a large proportion of insoluble matter would not have appeared: although the oxalic acid will detach lime

from the sulphuric acid, it also forms a very insoluble compound, and the arrangement of its acid and base is not very materially different from gypsum. From the result of my experiments, I have not found the oxalic acid to act very readily on the sulphate of lime in its dry state; it seems to require for its proper agency that the acid combination of lime shall be such as to be soluble in water, as is the case with the muriate or nitrate of lime; the small portion of sulphate of lime water is enabled to dissolve, the oxalic acid then acts as a very sensible re-agent. This circumstance, relative to the oxalic acid, is easily illustrated by the following experiment:—If we mix 24\* grains of the oxalic acid with 14.4 of lime, an oxalate of lime will be formed, and no excess of either. When these are well mixed, and boiled in distilled water, we ought to find 38.4 grains of the oxalate of lime non-decomposable by any of the acids; if on this we pour muriatic acid, evaporated nearly to dryness, and then boil it in some distilled water, we always find a considerable deficiency, and trace muriate of lime in the water.

Pure oxalic acid will not precipitate all the lime from a solution of the muriate, for the muriatic acid evolved

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\* I have adopted the proportion given by Dr. Thomson in his valuable paper on the oxalic acid, published in the *Philosophical Transactions*.

will retain some portion in solution. We generally find it more convenient to detach the acid from the sulphate of lime by double affinity, viz. the carbonate of soda in excess, the soda combining with the acid whilst the carbonic acid is arranged with the lime, and precipitated in the form of a carbonate. Even when oxalic acid is employed, the result will be more correct if we make use of its combination with ammonia.

Dr. Gibbes observes, that to six grains of this substance he added 12 of soda, and which he exposed to a high heat in a platina crucible; that it acquired a vitreous appearance, and suffered a very considerable effervescence, similar to that in making glass. The same circumstances attend gypsum. Klaproth notices, in his valuable experiments on the influence of porcelain fire on stones and earth, that gypsum is converted into a clove brown glass with large spherical air bubbles; and Saussure also remarks, that under the blow-pipe the sulphate of lime gives an opaque vitreous globule.

When any doubt is entertained as to a substance being silix, it is determinable by dissolving it in three times its weight of potash, in a silver crucible, exposed to a red heat. The silicated potash is soluble in water; and, if precipitated by the muriatic acid in a gelatinous form, and found, when dry, to correspond in weight, no doubt can be entertained as to its being silix.

Dr. Falconer, in his very valuable treatise, remarks, that an effervescence took place, when he poured some nitrous acid on the residuum; and a portion was dissolved, which was not affected by water alone; it was the carbonate of lime, giving out its effervescing acid, and forming a soluble salt with the nitric acid.

From these experiments, it appears that in 400 grains of the gross residuum there exists

Sulphate of lime . . . . .	231
Muriate of soda . . . . .	84
Sulphate of soda . . . . .	45
Carbonate of lime . . . . .	22
Oxy-carbonate of iron . . . .	5.6
Silex . . . . .	5
Variable quantity—Vegetable extract . . . .	2.5
	<hr/>
	395.1
Loss . . . . .	4.9
	<hr/>
	400.0

I have already remarked, that the gross residuum, after the evaporation, from each spring, is considerably discoloured; it arises from a vegetable extractive matter, which evinces a carbonaceous principle, from its effect on colourless sulphuric acid. About July, August, September, and October, when the Bath water is long pre-

served in a reservoir, an oiliness appears on the surface, which, when accurately examined, proves to be a vegetable substance of the cryptogamia class. From the process of boiling, it is this vegetable matter that gives the carbonaceous tinge; and it varies in proportion, according to the time of year. This substance is conveniently separated by alkohol; for in alkohol, highly rectified, none of the gross contents of the Bath Waters are soluble—Four ounces of alkohol were poured on 400 grains of the discoloured salt, and infused for three days, when the spirit assumed a dark brown tinge; this was gently distilled, and a brown mass was left behind, which weighed  $2\frac{1}{2}$  grains, and the whole nearly inflammable. The above salt was procured by evaporation in September; in January or February the salt is but very slightly discoloured.

I subjected to the same analysis 400 grains of the gross contents from each of the other springs, viz. the Hot Bath, the King's Bath, and the Cross Bath. The two former evinced the same proportionate parts with the Kingston water, the shade of difference not being more than what frequently attends two analyses of the same compound. The investigations of the four salts were made at the same time, under the same conditions, and exposed in their various stages to the same temperature, to guard as much as possible against any error.

The Cross Bath water gave out a much larger proportion of a calcareous salt than of the alkaline salt.

*400 grains decomposed.*

Sulphate of lime ..... 276

Carbonate of lime ..... 28

Sulphate of soda ..... 52

Muriate of soda ... ..... 29

Carbonate of iron ..... 4

Silex ..... 4

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393

The reason of this difference, relative to the Cross Bath, appears easy of explanation, from what has been communicated to me by an eminent geologist of this city, viz. the intermixture of common spring-water in the reservoir holding the hot water, which occasions in those springs a greater fluctuation of temperature than what is observed in any of the others. On this account these waters are deemed the weakest. In fact, it is the same as diluting a glass of water from any of the other hot springs with some common spring-water.

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## CHAP. VI.

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### OBSERVATIONS ON THE SILEX AND THE CARBONATE OF IRON, AS CONSTITUENT PARTS OF THE BATH WATERS.

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**I**T is in volcanic regions that hot springs appear in the greatest quantity, and display the most striking phenomena. We are informed by Von Troil, that at Laugervarm, a small lake two days' journey from Mount Hecla, there are hot spouting springs rising to an elevation of 24 feet; and yet, on their descent, retaining the temperature of boiling water, in which a piece of mutton and some salmon-trout were almost boiled to pieces in six minutes. At Geyser there are forty or fifty spouting springs within the compass of three miles, some of a white and others of a red appearance: the largest, Von Troil observed, was 19 feet in diameter, not

emanated in one continued stream, but projected at intervals nine or ten times a-day to a varying elevation from 30 to 60 feet; and once he remarked it as high as 90 feet. Previous to each evolution, there was a tremulous motion of the earth, and a noise resembling a battery of cannon.\*

One of these boiling jets, Bergman observed, has formed for itself a calcedonous crater, from the deposition of siliceous matter, and into which the elevated water is returned at the extraordinary temperature of  $212^{\circ}$ . It was impossible, from local circumstances, to ascertain the heat of the water at the point of evolution, but it was probably at a temperature of 3 or  $400^{\circ}$ . The expansive power of steam at such an elevation of heat is

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\* Sir Wm. Hamilton has described some curious hot springs near Ischia and Viterbo. About 60 yards from the shores of the island of Ischia, a column of boiling water bubbles on the surface of the sea with great force, and communicates heat to the water of the sea near it; it boils in winter and summer, and is of great use to the inhabitants in bending their planks for ship-building: the fishermen also avail themselves of this boiling pot to cook their fish. Sir Wm. also says, that in many places he found the sand, when bathing in the sea, too hot for his feet.—There is a boiling spring near Viterbo, called the Bullicanie: it is a circular pool about 60 feet in diameter, and very deep, constantly boiling, situated in a plain surrounded by volcanoes; a stony concretion floats on the surface, which is carried off by the superfluous water, and its deposits form tufa.

adequate to overcome amazing resistances, equal to 80 or 90 lbs. for every square inch. Sir J. Hall has shewn us, by his beautiful experiments on the carbonate of lime, what effects may be produced by the agency of heat on confined carbonic acid, in rendering lime fluid; and probably water, at a high temperature in a confined vessel, may be enabled to act on so refractory an earth as silex; but every attempt to fuse this earth has hitherto failed.

I have directed on silex a united stream of oxygen and hydrogen, which readily melts platina, without producing any effect. Saussure says, he fused, with a common blow-pipe, a very minute portion of silex, so as to require the aid of a microscope to examine it; but it should be remarked, that he placed the silex on a filament of cyanite, which only assumes a white appearance at the greatest heat to which it has hitherto been exposed; yet as cyanite contains alumina, magnesia, silex, iron, and lime, this is an arrangement of materials less refractory than pure silex.

Although fluoric acid will dissolve, and even in its gaseous state will carry with it silex, I have never hitherto been enabled to discover any such solvent powers in water at any temperature to which it has been exposed under our atmospheric pressure. It has been stated, that 10,000 ounces of water would dissolve one ounce of silex, and that one-tenth of that quantity would

suffice for fresh precipitated silex from the silicated potash. I took 20 grains of silex, which had been boiled\* with nitric acid, then washed by water, having been exposed to a red heat, and reduced to a very fine powder in an agate mortar: the silex was placed in a platina crucible, and immersed in 50 ounces of distilled water; the vessel in which the water was boiled was made of copper; the boiling was continued for two hours, and then left simmering in a sand bath for some hours. The platina cup was removed the next day, and the silex dried and weighed, without any sensible loss.

When silex is discovered in any mineral water, may it not arise from its being gently detached from its alkaline combination in that light flocculent state, so as to be mechanically suspended by the water? I invariably find that in Bath water, when kept quiescent for many days, there is a siliceous deposit, which would only admit of a mechanical admixture, and not of any chemical combination. In the case of procuring silex from the silicated potash, the precipitated silex requires some

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\* As silica, even in the state of quartz, is combined with a minute portion of alumina and lime; with a view of detaching these earths, the nitrous acid was employed. Although probably the combination between the silex and the other two earths might resist the agency of the acid as to separating the whole, this would not operate as an objection, as to any solvent power of water relative to silex being accurately ascertained.

days before it has completely subsided. That silex in these instances is only mechanically suspended, was also conjectured by the celebrated Bergman: "En évaporant l'eau des fontaines d'Upsal, apres les avoir filtrées plusieurs fois, j'y trouve toujours, a la verité, un peu de poudre siliceuse; mais il est certain que le silex est dans ce cas d'une telle subtilité, qu' une fois mêlé avec l'eau, il y reste suspendu par le frottement; car la division augmente les surfaces, & avec elles le frottement, qui équivant enfin à l'excès de poids qui provient de la gravité spécifique."

The slightest agitation diffuses the finely divided silex through the water, and may account why, in a flowing spring, it may be kept suspended.\* Klaproth remarks, that silex may be dissolved in water at a high temperature. Thus, the Geyser waters, according to Dr. Black's analysis, contain  $\frac{1}{1851}$  of silex; and the Carlsbad,

\* We find that many bodies, specifically heavier than water, when minutely divided, are for a considerable time kept mechanically suspended. This has been erroneously attributed to a multiplied increase of their respective surfaces; any division, however minute, can never affect the specific gravity of the substance: an infinitesimal of gold still bears the same ratio to a corresponding particle of water. The reason of the suspension depends on the diminution of the absolute weight, not enabled quickly to overcome the mechanical resistance, from the aggregation of the particles of the fluid; upon the same principle as a fine needle is easily made to float on water.

Klaproth observes, contain  $\frac{1}{11253}$ ; or 100 cubic inches of water contain  $2\frac{1}{4}$  grains of silex. This difference he attributes to the superior temperature of the Geyser to that of the Carlsbad. If the quantum of silex be in proportion to temperature, (as the average heat of the Carlsbad waters is  $165^{\circ}$ , and that of the Bath Waters only  $115^{\circ}$ ) it will render the proportion of silex in the Bath Waters very minute, not easily to be appreciated. In the Carlsbad and the Geyser waters there is found some uncombined soda, which, Klaproth conjectures, may arise from some decomposition of the muriate of soda, arising from the high temperature to which it is exposed. The disengaged alkali, under the influence of the same high heat, will enable water to act readily on any siliceous matter over which it may pass. In the Bath Waters there is no uncombined soda or potash, or either of these alkalies, in a state of carbonate,—a circumstance that would lead to the conjecture that the hot waters of Bath have never, in any part of their circulation, acquired a temperature much superior than that which they present to our attention.

Water, frequently distilled in glass vessels, has been long known to abrade the polished surface of the glass by acting upon that substance; but glass is a preparation of silex and alkali; and in consequence of this latter substance, we may explain the solvent powers of water for glass.

When silex is precipitated from a solution of silicated potash, we are not quite certain whether the muriatic acid has not some effect on silex, or that a portion of the alkali may not be precipitated with the silex; in either instance the capability of water to dissolve the silex will be easily explained. As silex, in its most minute state, is inodorous, tasteless, and insoluble in any of the animal fluids, we cannot attribute to its agency any medicinal property; no experiments, made with silex in any of its combinations either with the alkalies, the fluoric, boracic or phosphoric acids, have ever evinced any capability of acting on animal substance: a solution of silicated potash, poured into a solution of gum, produces a white flaky precipitate; and also, into a solution of aluminated potash, it forms a dark-coloured zone of alumina and silex. None of these arrangements evince any power of affecting the animal body.

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## CHAP. VII.

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### ON THE CARBONATE OF IRON.

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**T**HE small portion of iron detected in the Bath Waters is found to be in combination with carbonic acid, an arrangement insoluble in water, but which is kept in a state of solution by the carbonic acid gas intermixed in the water. As all gaseous fluids retained by water are mechanically compressed by the agency of an external power, such as atmospheric pressure, in proportion as this pressure is increased, so is the quantum of gas. Water, at the temperature of the hot springs, when only under the influence of atmospheric pressure, will not retain any carbonic acid gas: this being evolved, the carbonate of iron becomes precipitated in an ochrey-like appearance. Thus, the sides of the reservoirs are loaded with this matter, which gives a yellow ferruginous tinge to every substance where it may be deposited. Dr.

Gibbes has remarked, that there is some iron in a volatile state, which he deemed to be in its metallic character; and to this subtle chalybeate, he supposed, many of the properties of the Bath Waters are to be attributed. This supposition of Dr. G. has been objected to, from the principle, that carbonic acid gas cannot, as hydrogen gas, volatilize iron, or hold it in its gaseous form in solution. From many circumstances, I am induced to believe with Dr. G. that iron is evolved, either existing in the disengaged carbonic acid, or in the watery vapour, but detached in the form of a carbonate. We frequently observe hydrogen gas taking up with it zinc or iron; so also water, in the process of slacking lime, carries with the ascending vapour a portion of that earth. Sulphuretted hydrogen will carry with it a variety of substances, and fluoric acid gas even holds silex in solution. That iron is disengaged in this form is evident, from the vegetable-like efflorescence on the plaistered ceilings over any of the baths. I have one thus constructed, which in a few weeks is covered with a delicate downy substance, the fibrils being some inches in length, very much resembling in appearance the sulphate of magnesia\* in coal-mines;

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\* I have observed in the coal-mines at Whitehaven an appearance of this kind, the chrystallized fibrils not exceeding in length two inches; but my friend, Mr. Knox, one of the proprietors of the alum-quarries near Glasgow, lately informed me,

and also the plumose aluminous schist, such as is abundantly found near Glasgow. Upon examination, this efflorescence consists of the nitrates of lime and of magnesia, of vegetable extractive matter, and of the carbonate of iron. It is by no means uncommon for the Bath stone, to have a downy mould upon it, formed of the nitrates above-mentioned. I have never yet observed any traces of vegetable materials on that stone which is not exposed to the air.\* It appears that the carbonate of iron is detached from the Bath water. To ascertain whether this is the case, I suspended over a bath, holding 150 hogsheads of hot water preserved in a constant state of circulation, a large piece of calico, previously well dipped in a solution of galls; in four days

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that they discovered in one part a considerable space of ground having a beautiful vegetable appearance, like as, he says, to a field of corn, the filaments being equally as long, and the whole consisting of sulphate of magnesia.

\* On a house, recently built of Bath freestone, there will soon be observed a partial growth of moss, not confined by any circumstances as to situation, apparently depending on the condition of the stone itself. The Bath freestone is of that species called the roe-stone or oolite, from its granulated arrangement like the roe of fish. It appears that the moss-seeds floating in the atmosphere are deposited in that portion of the stone where the interstices more easily admit; hence, the coarser the granulated arrangement, the more disposed to find a nidus for the vegetable evolution. When the vegetable matter becomes carbonated, it forms that black discolouration that is soon observed, and gives a firmness of texture to the superficial part of the stone.

the discolouration was very evident, and in three weeks it was very satisfactorily distinct.

It may be urged by some, that the quantity detached from the comparatively small portion that is drank, cannot admit of any appreciation, and therefore incapable of producing any sensible effects on the animal frame. We have yet to learn the precise power of substances on the constitutions according to their different states of exility, and according to the part of the body to which they are applied: the stomach will not be disturbed by the same substance which will powerfully derange the lungs. A great number of metals are capable of being volatilized by heat or other powerful agents. I am not acquainted with any, except mercury and zinc, which can be volatilized in their metallic state. The protoxides of gold, silver, and copper, are easily volatilized by galvanism; so most of the other metals in some states of combination will undergo a similar change, as the carbonate of lead when used as paint.\* As the proportion of the carbonate of iron, in-

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\* In a recently-painted room there is a substance volatilized which arises from the agency of oil or turpentine on lead: it is insoluble in water, yet it is common to place a vessel of water to prevent any ill effects from the paint; the water is observed in a few days to have a brownish film on its surface, and which is found to contain lead. The best protection is to sprinkle vinegar on the floor; this is volatilized by a small increase of temperature, combines with the lead, and the compound is immediately precipitated.

roduced into the stomach, is too minute to account for the tonic and stimulating effects we observe from the use of the Bath Waters, it is possible that a small portion, assuming a gaseous form, may, by inhalation, produce some effects on the lungs. It need not be observed to the medical practitioner that different effects are derived from the same substance on the different viscera: thus, carbonic acid, disseminated through liquid medica, is highly refreshing and agreeable to the stomach; but when applied to the lungs, it acts as a depressing poison; so the gaseous oxide of azote of Dr. Davy produces no particular effects on the stomach, whilst the remarkable exhilaration of spirits it induces, by its agency on the lungs, has been satisfactorily evinced by a variety of experiments.

It is supposed by some that iron exists in the Bath Waters in three states, viz. in the carbonate, in the protoxide, and sulphurated state; from the careful examination to which I have subjected the solid matter appertaining to the Bath Waters, I have never been able to detect iron existing in any other state than in that of a carbonate. The sulphuret of iron found in the sand has no connexion with the water; and for the existence of iron, in any of its oxidized states, I am persuaded, is perfectly imaginary.

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## CHAP. VIII.

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### ON THE SAND AND THE ORGANIC REMAINS OF ANIMAL AND VEGETABLE MATTER OBSERVED ON THE BEDS OF SOME OF THE HOT SPRINGS.

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**I**T is generally supposed that the sand which is found on the bed of the King's Bath rises up with the spring; there are found in it nuts, bones, and magnetic iron, all of which are imagined to have originated from some remote source, and to have been thus determined by the agency of the spring.

The sand, when examined, is precisely the same as that which is found on the banks of the Avon, deposited there from the washing down of hills some miles above Bath; both of them contain magnetic iron, similar earthy ingredients, and organic remains. The proportion of magnetic iron is greater in the river-sand than in the bath-sand. Upon detaching all the iron that the

magnet could influence, I poured upon it some nitric acid, and boiled it for some time nearly to a state of dryness; upon this I poured distilled water, and barytes evinced the existence of sulphuric acid; so that the iron exists in the sand in the state of a sulphuret. Common sulphuret of iron is not magnetic.

Relative to the proportion of the constituent parts of pyrites, there is a material difference in the analysis of Proust and of Hatchet; the former making the sulphur 52.6 per cent. and the latter only 46.7. From the results of my experiments, pyrites is not magnetic when it contains a larger proportion of sulphur than 35 per cent. After oxygenating the sulphur in the pyrites found in our river-sand by the concentrated nitric acid, diluting the solution by water, and precipitating the sulphuric acid by the muriate of barytes, the proportion of sulphur was ascertained, according to the analysis of sulphuric acid by Klaproth, viz. of the acid containing 42.5 per cent. of sulphur.

The nodules of pyrites, discovered in the sand of the King's Bath, even when powdered, evince no magnetic quality; it seems necessary that the sulphuret of iron should be in a finely-divided state whilst under the influence of water, and under these conditions the relative proportion of sulphur becomes diminished: a similar

change takes place by the agency of fire. A piece of common pyrites, powdered and exposed to a red heat in a common culinary fire, rarely loses more than 15 or 16 per cent. of sulphur; after this operation the iron becomes magnetic. I have exposed for some months powdered pyrites to the influence of the hot springs; as yet I have not discovered any sensible change as to its magnetic property.

The bones and nuts discovered in the sand are not evolved by the spring, these were brought along with the alluvial matter which has been appropriated to the elevation of the lower part of Bath. There is reason to believe that the lower part of Bath was formerly covered with water, forming an extensive marsh or lake: by a progressive elevation of the ground, the waters were reduced into narrower dimensions as to have been ultimately contracted into the channel, now constituting the river Avon. The blue marl, forming the bed of the then known hot springs, was gradually covered with alluvial matter, in which these animal and vegetable recrements are found. The bottom of the river Avon and the surrounding soil would be simultaneously raised by the deposit of the substances which the Avon brought from the higher grounds. This work of nature has been accelerated by art; the inhabitants, to protect themselves from these encroachments, have brought new accession of soil to the grounds

which they occupied. The materials by which these elevations have been effected, correspond with the constituent parts of the higher grounds, through which the Avon is determined. The silex, small shells, and the sulphuret of iron, are the principal constituent parts of the sand carried down by the river; the silex, when examined by the microscope, corresponds exactly to siliceous pit-sand, from its unworn angles, evincing a sharpness which is soon destroyed when subjected to much motion, as is the case with river and sea sand. Some of these little quartzose crystals have an emerald, and others a ruby kind of tint: the carbonat of lime exists in a small proportion, and seems entirely to arise from the shells; alumen and gypsum also form a small part.

Dr. Falconer, in the preface to his valuable Dissertation on the Bath Waters, remarks, that the buildings which formed the Cross-Bath were taken down in 1784; and while this was going on, in several interstices in the lower part of the building contiguous to the channel by which the water was discharged from the baths, but above the level of its course, were discovered a considerable quantity of a crystallized substance, variegated with several colours. Dr. F. remarked that it was inflammable, had a sulphureous smell, and gave a chalybeate taste to water. Dr. Falconer presented me with a small portion to analyze. Nitric acid, boiled upon it nearly to dryness, rendered

the whole soluble in water, and proved to be sulphate of iron. From the circumstance attending this substance, Dr. F. was induced to suppose it was volatilized; the sulphuret in this state was not magnetic.

The relative elevations of the different beds of the Hot Bath, the Cross Bath, the King's Bath, and the Kingston Bath, were well ascertained at the great flood in January 25, 1809; the flood-line was  $7\frac{3}{10}$  inches below the bottom of the King and Queen's Baths, 7 inches above the Cross Bath, 2 feet  $6\frac{6}{10}$  above the bed of the Hot Bath, and 8 feet  $2\frac{3}{10}$  above the Kingston Baths.

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CHAP. IX.

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ON THE AGENCY OF THE BATH WATERS  
TAKEN INTERNALLY.

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**D**R. Saunders, in his valuable Treatise on Mineral Waters, observes, that the Bath Waters produce their principal effects by their temperature alone; so likewise the learned Heberden has remarked, that no chemical analysis of the Bath Waters can do much towards ascertaining the virtues of those mineral springs; but that almost all our useful knowledge of them, as medicines, must be gained from experience. However these observations may apply to the external use of these waters, yet Dr. Heberden (by no means an advocate for their use) allows, that internally these springs are of singular use in remedying the morning sickness and vomiting, the loss of appetite, pains of the stomach, and other ill effects of hard drinking. The probability of considerable benefit, he ob-

serves, will make them worth any one's trying who is afflicted with indigestion, a chronical diarrhœa, hiccup, flatulency, vomiting, or any spasmodic affections.

Dr. Saunders has reduced the catalogue of *diluentia* to a single article, viz. pure water, employed at different temperatures, according to the indications pointed out by different symptoms: he observes, that the tepid waters of Bristol or Bath never produce any weakening effect on the stomach, but, on the contrary, the appetite and general health are improved under the use of them; and it does not appear that in any of the thermal springs that we are in the habit of using medicinally, their high temperature counteracts the invigorating qualities of their foreign ingredients. Delicate and irritable stomachs often require a tepid warmth to be given to their drink; for the process of digestion may in these habits be suddenly disturbed by a draught of cold water. It is observed by Dr. Wall, that the Malvern water, so remarked for its purity and being divested of every metallic principle, on its first use frequently induces drowsiness and occasionally a dull pain in the head: the doctor rationally conjectured that these effects must be owing to the ready and easy admission of the water in the blood, whereby a plethora is brought on *pro tempore*. Such is the effect frequently experienced by the introduction of an unusual quantity of the purest water at the common temperature into the

stomach; whilst, on the contrary, we find that, by prudently increasing the quantity of water in the fluids of the body, we diminish the stimulus of the circulating fluid in the whole vascular system during acute disease, and thereby moderate the heat, thirst, and violence of re-action in the solids. If caution be required as to simple dilution in actual fever, if we are apprehensive of increasing effusion to a morbid degree into the cavities of the body, a greater degree of care will be required when the diluent fluid is combined with any principle of a stimulating nature, as is the case with the thermal mineral springs of this city. As most of the general diseases with which we are afflicted originate in the stomach, as every part of the animal economy has a sympathetic connexion with this viscus, it is from the actions we induce on this organ we influence the whole frame. Let us examine those numerous instances where nature languishes under a load of intemperance: she painfully tells us whenever we transgress those just bounds she hath prescribed. Every man in his own constitution carries a proper standard of temperance or intemperance. The stomach was never designed to be a repository of all that discordant variety which a luxurious and depraved appetite can crave; ransacking nature for delicacies, plundering earth, sea, skies, to furnish them with the miserable means of gratifying appetite!

By thus overloading nature, they incapacitate her for performing her regular functions with facility and efficacy. The weight of excess soon breaks the strings of this exquisite instrument, the human frame: all is discord; the body languishes while not unfrequently appetite rages—a gout, a palsy, an asthma, or an apoplexy, finishes what excess began.

It is by some imagined that many diseases are the necessary attendants to particular corporeal conformations; and hence, the child which resembles in form its father, grandfather, or ancestor, in more remote degree, will take on the same corresponding diseases. It is true that similar corporeal arrangements, under the influence of similar causes, will take on corresponding actions; when these actions are of a morbid nature, it is our duty to avoid the exciting causes. Under all these conditions, by simplicity of diet, most would measure out the whole period of present existence allotted to them without pain or distemper. We have a remarkable illustration of this, in the Life of Cornaro, who originated from debilitated parents, and himself possessing an infirm and delicate frame, yet, by prudent abstemiousness, lived nearly one hundred years, and died in his elbow-chair without pain. It was with Cornaro a common saying, that when we are sitting down to a luxurious feast, that which we leave does us the most good.

When we compare the loaded tables of the present day to the simple entertainments of former times, we cannot be surprized at the list of human calamities being increased, and medical men in a greater state of requisition. Homer represents Achilles inviting Phoenix, Ajax, and Ulysses to an entertainment: Achilles sets on the fire a great pot, and puts three chines into it; Automedon, his charioteer, holds the meat, whilst he himself spits it; and Patroclus blows the fire. So also, in the pure ages of the Roman republic, dictators and consuls were employed in the most laborious offices of agriculture. Horace tells us that Lælius and Scipio used to pass the vacant hour with Lucilius, the old poet, while the cabbage was boiling.

Thus, all the great men who lived abstemiously lived to a good old age. Pythagoras and Hippocrates lived to one hundred; Sophocles at ninety produced his Oedipus; and Pindar, who begins his poem with *Ἀγνιστον μὲν ὕδωρ*—*Water the best thing in nature*, lived to near a century; a motto rather injudiciously applied, where mineral waters are drank, as only intended for the pure unmixed stream: Diodorus Siculus tells us, that the primitive inhabitants of Britain were distinguished for the simplicity of their manners and their food; and Plutarch says many lived to one hundred and twenty. Those in modern times who

have arrived at a great age, have been remarked for the small quantity of animal food they have taken: thus, Henry Jenkins, who lived one hundred and sixty-nine years, and old Parr, one hundred and fifty-three, subsisted principally on milk and vegetables.

It is well known to every medical man, that excess in drinking is not so injurious as excess in eating. This is one of the aphorisms of Hippocrates; and Celsus also remarks, “*Siqua intemperantia subest, tutior est in potione, quam in escâ*: and the celebrated historian Pliny judiciously observes, “*Homini cibus utilissimus simplex, acervatio ciborum pestifera, et condimento perniciosior.*”

Although an excess of watery liquid thrown in faster than the emunctories can carry it off, must induce a temporary plethora in the blood-vessels, yet it is ascertained from the experiments of Mr. Carlisle, that the absorbents of the stomach will be additionally active in removing the excess. This can by no means be the case with animal food; to the excess of which, combined with its stimulating condiments, most diseases are attributable.

There are some complaints which are supposed to be endemial in certain countries, and to originate from peculiarity of climate. Thus, scrofula, and all its direful concomitants, phthisis, &c. are said to be endemial in the British isles; calculus and gout are thought to be more frequent in France; the goitre and cretanism, in the Alps;

and the lepra and elephantiasis, peculiar to the eastern countries. These complaints are in a great measure obviated by an attention to simple and healthy food, to cleanliness, and to the preservation of the body from sudden changes of temperature.

From the observations of Drs. Heberden, Baker, Warren, Darwin, and Lambe, it appears that paralytic affections have considerably increased; and this increase has in many instances been attributed to the various modes by which lead is introduced into the system.

When we consider that the water, which is generally employed for culinary purposes, is in many towns determined through lead pipes, and allowed to stagnate in lead cisterns, or pumps constructed with leaden pipes, in all these cases, water, when containing any sulphate or carbonate of lime or muriate of soda, or any animal or vegetable matter, ingredients which more or less are found in most waters, lead becomes very perceptibly acted on, and this insidious poison introduced into the constitution. In the case of Sir G. Baker, in Lord Ashburnam's family, to which spring water was supplied from a considerable distance in leaden pipes, the servants were every year tormented with colic, and many of them died paralytic. The water was analyzed by Dr. Higgins, who found a large proportion of fixed air and lead in solution. Lord

Asliburnam substituted wooden for leaden pipes, and his family have had no particular complaint of the bowels since.

Lead is introduced into the constitution from various other sources, as milk in lead vats,\* meats salted in vessels of lead or glazed with lead; and more particularly from the present construction of beer-engines, where the beer is pumped up through leaden pipes of thirty, forty, or fifty feet in length; as beer frequently undergoes the acetous fermentation, the pipe, when examined, evinces signs of being rapidly acted on, and so soon corroded, that I know in some instances copper pipes tinned have been substi-

\* In Devonshire, Cornwall, &c. where clotted cream is employed, the milk is kept in large brass pans, in which it is simmered, by which means the cream rises to the surface in an intermediate state between cream and butter; and in extensive dairies so little attention is paid to cleanliness, that I have frequently observed a green tinge in that part of the cream in contact with the vessel. Equally pernicious is the adoption of lead vats, from an idea that more cream rises: in fact cream is thickened by the smallest portion of lead; a few drops of the goulard extract will considerably thicken a teacup-ful of cream. As some advantage arises to the dairy-keeper in having the milk quickly cooled, this is very conveniently and safely effected by means of shallow tin vessels. Persons accustomed to drink cider should not only be careful that there is no lead employed in the mill or the vat, nor should they allow a brass cock to the barrel, as wooden ones are best.

Dr. J. Hunter traced lead in new rums, from the distillation through worms containing lead.

In British spirits and whiskey it is common to add to the wash some vitriolic acid, to give an ethereal smell.

In these and in distilled vinegar lead can be traced.

tuted from a principle of economy alone. To this cause I have long been persuaded is to be attributed the increase of paralysis amongst that class of persons who frequent public houses; and in many instances I have been induced to examine the residual beer in the pipes when first pumped up in the morning, and rarely have failed in detecting a considerable proportion of lead. Another very dangerous source is the refining of some of the strong bottled ales by lead, and the pernicious practice of employing shot in the cleansing of bottles, many of the corns frequently become strongly impacted at the bottom, and acted upon by the wine or beer put into it; by this means the arsenic which is employed in the rounding

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When Hollands is tinged by the cask, sugar of lead is employed to clear it. Dr. Shearman mentions many cases of persons destroyed by this method.

In butter preserved in earthen vessels, lead is traced: the glazing becomes corroded, and after a second winter the vessel is no longer fit for use.

Mr. Deering mentions a case of many persons being destroyed by sugar packed in a white-lead cask.

When lead is introduced into the constitution by exposure to large quantities, as with painters, plumbers, &c. it then induces spasm, convulsions, a sallowness of countenance, and diminution of muscular substance; when introduced in very small and gradual portions, it occasions a lingering indisposition and constipation for many years, a loss of motion in some of the limbs but not of sensation, and no other extenuation of flesh than what arises from inactivity.

Upon dissection, no traces of morbid affection are discovered.

process of the shot, and the lead acted on, are introduced into the constitution. It is not only paralysis produced by the poison of lead, it is also observed, from its peculiar action on the stomach and intestines, that scrofula, phthisis pulmonalis, dropsy, chronic rheumatism, dyspepsia, bilious complaints, hypochondriasis, and various nervous affections, in many instances, originate from this concealed and insidious poison.

Although every person exposed to its influence must feel, in a greater or less degree, its debilitating and depressing powers, exhausting the vital energies, and accelerating the advance of old age; yet, from the variety in the constitution of the human frame, a corresponding variety as to its effects are observed.

Water, in its purest state, is occasionally liable to be impregnated, even from simple atmospheric exposure, with animal and vegetable matter, and thus enabled to act on lead: how extremely cautious then ought we to be in permitting water, charged with any combinations with the sulphuric and muriatic acids, to pass through pipes containing any lead in their composition! and as these decompositions are increased by the increase of temperature, that is the reason why the warm springs of Bath produce such sensible changes on lead.

Dr. Falconer, whose accuracy of observation is well known, says, that the leaden cistern, which served as a

reservoir for the spring that supplies the King and Queen's Baths and the great pump-room with water, was plentifully corroded on its inside by the long furrows which are visible on every part of it; and if the pipes which supply the different pumps with warm water in this city are principally formed of lead, a considerable portion of this dreadful poison must be continually introduced into the constitution.

It unfortunately happens, that when once a person has been afflicted with the saturnine colic, he is more susceptible of a second disturbance; and, as invalids who have recourse to Bath Waters are, those whose stomach and intestines are frequently in a state of great debility, they become proportionately more sensibly acted on by this metallic poison.

From a conviction of the deleterious effects arising from lead, I have had all the pipes formed of that metal removed, which were laid down in the reservoir appertaining to the Kingston Baths, and have covered the spring with a porcelain vase, from which, by a series of pipes made of the purest and unalloyed tin, a metal which is well known to every chemical person to be incapable of being acted upon by any of the saline contents of the Bath Waters, and even, if held in solution, perfectly innocent in a medical point of view, continued to the pump which supplies the Kingston Pump-Room. It being now ascer-

tained, that when dissimilar metals are in contact, and exposed to the influence of any fluid capable of producing chemical changes upon either of them, such agencies are more rapidly effected; hence, water, when determined through leaden pipes in contact with iron, acquires a chalybeate taste, and, by remaining in a glass, will frequently give it a ferruginous tinge: when this is observed to take place suddenly, it invariably marks the impregnation to be artificial; an effect never observed in the natural water of the spring.

As tin does not possess sufficient ductility to allow of any circuitous course, when drawn into pipes of large dimensions, on this account the diminished size of the pipes, not admitting of a large volume of water, become sooner cooled; and hence the substitution occasions a slight diminution of temperature. This little sacrifice of warmth, which occasions not the slightest alteration as to its medical properties, and in many delicate constitutions preferable from circumstances (as will be hereafter stated,) is most amply compensated by having the water raised through pure and innocent tubes, perfectly freed from any metallic poison, and the pump formed of the same innocuous metal.

I have observed in the preceding pages, that most diseases are of our own creation; and even when there exists what has been termed an hereditary claim to certain

corporeal affections, such may be in a great measure guarded against by an attention to the circumstances I have already mentioned. From an organ so exquisitely sensible as the stomach, and with which every other organ of the body partakes of an intimate sympathetic affection, is the reason why in every corporeal affliction the attention of the physician is directed to this part. The valuable observations of Drs. Hamilton and Currie, and Mr. Abernethy, have satisfactorily proved that the principle of cure in most morbid affections depends on a restoration of the digestive organs to their natural state. Not only temperance, with regard to our food, is requisite, in an insulated country like Great-Britain, subject to very rapid vicissitude of temperature, proper attention ought to be paid as to the external protection of the body.

It is estimated, that upon an average twenty-four ounces of matter are daily evolved from the surface of a middle-sized person in these climates. When, from exposure, the perspiration becomes irregular or suppressed, there will be an usual determination of blood to some internal organ, as the lungs, head, &c.; and hence many diseases will originate from obstructions of the thoracic and abdominal viscera. Thus, rheumatism is comparatively rarely known either in cold or hot countries where the range of temperature is uniform; whilst in England this complaint, phthisis, asthma, and catarrhus senilis, are very common.

These complaints are, in a great measure, obviated by the application of flannel close to the body: from its absorbing quality it occasions no interruption to perspiration, and from its inferior conducting powers of caloric, prevents the skin being influenced by any quick changes of temperature. In winter it is the warmest medium to clothe the body; in summer the coolest, as in the one instance it prevents the dissipation of caloric, so in the other relative to the superior temperature externally.

When the nature of the disease and peculiarity of constitution have been ascertained, we shall then be enabled to determine how far the Bath Waters internally exhibited may be beneficial. We must regard the Bath Waters as a stimulant, by its temperature increasing the pulse and the warmth of the stomach; as a diluent holding in solution muriatic and sulphuric combinations, promoting the secretions, and, by its volatilized metallic matter, inducing some action on the lungs. Those who have carefully attended to the effects induced by equal quantities of common water and Bath Water at the same temperature, are well convinced of the more powerful stimulating effects of the latter; and, from my local situation, having the warm baths and pump on my premises, I have had superior opportunities of observing the effects of the warm mineral water on different constitutions, and comparing them with the effects of common warm water,

A person in full health, taking a glass of common water at the temperature of 110 degrees, experiences a warmth and a gently-increased circulation; whilst the same quantity of Bath Water will frequently induce an intoxicating kind of giddiness, a determination of blood to the head, and evince superior stimulating powers.

From the preceding analysis it appears that the small portion of saline matter held in solution cannot, from analogical experiments, be deemed as the exciting agents; and as it appears probable that there is some carbonate of iron detached in solution of corbonic acid gas, there may be some agency of this volatilized matter on the lungs.

In all cases of an inflammatory kind, or where there is an indication of too much blood being determined to the vessels of the brain, or any symptoms of an apoplectic nature, these waters should be carefully avoided; so also in pulmonary affections, and all complaints which would be aggravated by an increased circulation, the Bath Waters would be productive of mischief. When the organs of digestion are in a state of debility, arising from intemperance in eating or drinking, or connected with constitutional weakness, originating from other corporeal affections, in such cases the Bath Waters are found beneficial.

As the Bath Waters induce an increase of circulation, the utmost prudence is required on the commencement of their use; although they promote the secretions by the

skin and kidneys, yet they are not observed to possess any aperient property; hence, if there exist a state of constipation, it is advisable to have previous recourse to some gentle opening medicine.

In general, the quantity taken is from four to eight ounces twice a day, beginning with the smallest sized glass, and progressively increasing as the symptoms may indicate. With some practitioners it has been the custom of recommending the pump at the Cross Bath as the mildest to be commenced with, and to gradually proceed with the other pumps. A more accurate examination of the waters clearly prove that the Cross-Bath Water is only the hot spring water diluted with common water, which casually flows with it; and that all the other springs, viz. the Hetling-Court, the King's Bath or Pump-Room, and the Kingston Pump-Room, are all ramifications from the same common source, and possess the same medical and chemical properties.

From the preceding analysis, it appears, that the properties of the Bath Waters are preserved when the temperature is not less than one hundred degrees; hence a degree or two difference in the warmth of the water at the respective pumps merely depends on local circumstances, and not on any essential difference of the medical character of the waters at the different pumps. Thus, the poor man's pump, as it is termed, is the warmest, on account of there being the least length of pipe.

Some persons, from their stomachs being extremely weak, find the warmest water the most grateful; the effect is only temporary, and in many instances I have observed, ultimately, more beneficial effects by drinking the water at a little lower temperature than what would be produced by a continued long pumping.

In those cases where persons have complained of a cold sensation in their stomachs, I have successfully recommended a glass of water as high as 120 degrees immediately on rising, and an hour or two afterwards to take a glass of the Bath Water at a moderate warmth.

Those who are desirous of more extensive information as to the medicinal effects of the Bath Waters, I shall beg leave to refer to the dissertations of Drs. Falconer and Gibbes; only remarking, that, as the temperature of the stomach is 98 degrees, water at 108, being an accession of ten degrees, is as high a stimulus as this organ can with advantage support.

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CHAP. X.

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ON THE INFLUENCE OF THE BATH WATERS  
EXTERNALLY EMPLOYED.

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**A**LTHOUGH the temperature of the internal part of the body is observed to be nearly 98 degrees, the same regularity of temperature does not attend the external surface; this will undergo changes from various circumstances. In its natural healthy state, all accumulation of heat is prevented by the cooling process of perspiration, and to which refrigerating purpose the lungs\* considerably contribute.

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\* In the Elements of Galvanism published by me a few years since, I have there attempted to prove that the lungs are by no means appropriated to the purpose of regulating temperature; and have there shewn by experiments, that all the caloric detached from the oxygen gas, which is decomposed by the process of respiration, is no way proportionate to the continued expenditure. *Vide El. Galvanism*, vol. ii. 8vo. edit.

As the power of regulating temperature depends upon the principle of life ; when this becomes disturbed, a variation in the proportion of warmth necessarily follows, inducing an alteration in the quantity of matter determined from the skin.

Experience tells us that the perspiration is diminished by a higher degree of animal temperature than is natural, as much as by one that is too low. The exhaling vessels, the terminations of the arterial extremities appropriated to this purpose, perform not their office when the circulation is either too languid or too active.

Nature has wisely arranged, that the medium which surrounds our body should be an imperfect conductor of heat, otherwise the abstraction would be more rapid than the powers of life could supply. We even find a continued quick succession of fresh air cool the surface of our body considerably ; and hence we advantageously avail ourselves of this medium, when there is too great a determination of heat to the surface.

Under such circumstances, when heat is abstracted uniformly from the body, there is no danger. When a person during the night feels thirsty, a dryness of the skin, considerable heat about his hands, his pulse rather quicker than natural, and a restlessness, he will always

find himself benefited by walking about the room, without any additional covering, (guarding against any partial currents of air) till he feels the surface of his body restored to its natural state. On his return to bed, a gentle perspiration will frequently follow, and the balance of nature be thus restored.

When this morbid accumulation of heat cannot be sufficiently removed by what may be termed an air-bath, then substances of higher conducting powers must be employed, and which are necessary in many acute affections; as by rubbing the body over with a damp cloth, and immersing the hands in cold water as long as agreeable, or applying more evaporable substances, as the conversion into vapour operates as a very powerful cooling medium. By this treatment we frequently find the pulse, previously hurried and unsteady, restored to its natural state of calmness, and the delirious wandering thoughts, the characteristics of ardent fever, quieted in undisturbed sleep.

In dyspepsia, or any considerable derangement of the digestive organs, in all passive inflammatory complaints and paralytic affections, originating from a defect of nervous energy, and in every disease connected with a languid and debilitated circulation, warm bathing is productive of advantage.

When the body is immersed in a medium of a higher temperature than its own natural heat, the excess of warmth will act as a stimulus to every part of the body exposed to its influence.

Although the temperature of the natural part of the body is 98 degrees, the skin is generally some degrees lower. Hence, a bath at 96° will act as a stimulus on two accounts: first, by the direct application of an increase of temperature; and, secondly, by preventing the dissipation of the natural warmth through the medium of the skin.

When we reflect on the sympathetic connexion there exists between the skin, the stomach, and every other organ of the body, we may readily conceive the advantages we must derive by a judicious application of caloric through the medium of water.

In many complaints we find the circulation disturbed and unequal; one part of the body retaining its natural warmth, and another evincing an imperfect determination of blood to its surface. By the immersion of the body in a warm medium, every part is acted upon by the same stimulus, the circulation becomes equalized, and the skin restored to its uniform temperature.

As caloric is the grand stimulus employed by nature, the regulation of this, when adopted as a medical agent,

requires the practitioner's utmost care and attention. I have invariably remarked, that the difference of a degree or two in temperature, when below animal heat, never produces the same sensible effects as a corresponding difference when above  $98^{\circ}$ ; in general, it is adviseable to commence at about  $94^{\circ}$ , and to increase progressively as the symptoms may indicate. So, also, the same attention should be paid to the time of remaining in the bath, which, in the first instance, ought not to exceed five or six minutes, and to gradually increase to twenty minutes. As a warm bath is a luxury, many will indulge themselves for nearly an hour; in such cases, considerable debility ensues from the too long continued action of heat.

In every instance, whether a bath is used either for pleasure or relief, the active application of the flesh-brush to every part of the body is adviseable, as the saline contents of the Bath Water prevents it acting as a cleansing medium to the skin. The assistance of the brush becomes necessary to detach the perspirable matter, an action highly conducive to health, and particularly adviseable in cutaneous affections depending on some local affection of the skin.

When a person is removed from the bath, the greatest care is required that every part of the body be preserved in the same degree of temperature; the bathing induces

an additional sensibility, and renders the patient susceptible to the slightest current of air. It is not only necessary that the body should be well covered, but that the dressing-room be preserved in an equal degree of temperature, otherwise there will be constant currents towards the chimney, and the part of the body exposed to the fire will be warm and the other part chilly. I have known in many instances a sudden rheumatic affection to be produced by a partial exposure of this kind.

To protect the body from a circumstance at all times uncomfortable, and in many instances dangerous, the dressing-rooms of the Kingston Baths are peculiarly constructed with double floors, so as to admit of a constant circulation of warm water from the spring, of the dimensions of all the floors, and about two feet deep; by which means a steady uniform temperature, inducing a glowing warmth, is preserved in every part of the room.

As the active application of the flesh-brush to every part of the body, and an attention to the temperature of the water, are always requisite, in a public bath these important points must be sacrificed. The skin being morbidly sensible in most cases where the Bath Waters are advised, the patient, without any regulating hand, is permitted to expose himself to such different degrees of temperature as must considerably disturb the system.

When we consider, that when perspiration is suppressed, and, which is necessarily the case when the body is immersed in water, other secretions are promoted; and when we contemplate the variety of cutaneous affections; the idea is by no means pleasant in being immersed in the same medium which is the repository of what has been detached. Every individual that has a regard to health, to delicacy, and to all the advantages to be derived from warm bathing, will not only prefer a private bath adjusted to its proper temperature, but will also take particular care to have one fresh filled.

For so desirable a purpose the Kingston Baths are very happily constructed, from being situated considerably below the level of the reservoir; a bath is filled in a few minutes at any required temperature below 108 degrees, and a fresh bath for every person is rigidly attended to.

With some it has been a subject of dispute, whether there are any peculiar advantages attending the warm baths of this city over common water raised to the same temperature: the small portion of solid matter which the Bath Waters contain, cannot be supposed to be capable of producing any medical effects by its application to the external part of the body; indirectly it will act by preventing so absorbing a surface as the skin taking up

any portion of the fluid, from its incapability of detaching the perspirable matter on the surface. We might be induced to suppose that an absorption of water in a relaxed state of the constitution would not be beneficial. We certainly observe that common warm water in a slipper-bath, at the temperature of 100 degrees, does not produce the same increase of circulation as Bath Water at the same degree of warmth; and probably some effects arise from the head being surrounded by an atmosphere more or less charged with some of the volatilized carbonate of iron.

A slipper-bath is too confined for various purposes; it precludes the application of the brush, and prevents the extension of the limbs, which to an invalid is so grateful, as little exertion is required for their motion, when assisted by a fluid of the specific gravity of water.

We have many disorders in which the warm bath is more adviseable in some of its stages, and a cold bath for the completion of its cure; in such case a tepid bath about 90 should be used for some time, to prepare the body for a cooler immersion.

So, also, when a bath is employed only for purposes of simple washing, a tepid bath is preferable. For such cases I have constructed one of large dimensions, where the temperature is generally between 88 and 90 degrees.

## *On the Use of the Pump.*

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WHEN water is applied to any particular part of the body by means of a pump, whilst the remaining part of the body is preserved dry, in Bath it is denominated *dry pumping*, to distinguish it from the pumping upon any part of a person when in a bath, which is called *wet pumping*.

In many cases of a local nature, as in paralytic affections, rheumatic complaints, defect of motion in any of the limbs, such as originate from the lumbar vertebræ, or diseases in the hip joint, we require more stimulating properties than what would be derived from the temperature of the water; in addition to its warmth, we thus gain the advantage derived from its mechanical impulse.

As in these cases an increased stimulating property of the water is required, a higher degree of temperature becomes necessary than what would be recommended for general bathing; on this account it is adviseable for it to be four or five degrees above the animal tempera-

ture, and the force of the stroke regulated according to the nature of the case. The quantum of impulse is unfortunately not sufficiently regulated; so that it frequently occurs, that when so many strokes, as each pumping is denominated, are prescribed, the same impulse is indiscriminately given. The force of the water does not require the same accurate adjustment as the temperature; yet it is easy to arrange the pump so as to be capable of dividing its powers into three degrees, viz. the whole force of the pump, two-thirds, and one-third. This division is adopted at the powerful forcing pump appertaining to the Kingston Baths.

After dry pumping, considerable advantage is experienced by rubbing the affected part actively by the hand, after the manner recommended by the ingenious Mr. Grosvenor, of Oxford. With this view there is an attendant at the Kingston Baths properly instructed in the process.

In many instances of defect of motion, I have experienced great relief, not only by keeping the parts, or the affected joints, in as much motion as can with ease be borne, but also by actively employing a very warm embrocation, consisting of a solution of camphor in animal oil. It is a curious circumstance, that an aqueous fomentation at  $130^{\circ}$  is as hot as can be conveniently applied,

whilst the temperature of an oleaginous application is with advantage increased 60 or 70 degrees.

In paralytic affections of the hands, we generally find that the extensor muscles are more affected than the flexors, so that the fingers are generally preserved closed. This continued extension prevents the debilitated muscles recovering their natural energy; on which account Dr. Pemberton has very ingeniously recommended the placing of the hand on a board, preserving the fingers in a state of extension by securing the board to the hand and arm by tape.

From the great number of these cases which have been presented to my attention, I have been induced to make a slight alteration in the plan: instead of applying the board in the direction recommended by Dr. Pemberton, I have substituted elastic springs, in the direction of the extensor tendons, the tension of which I regulate according to the power required. By this arrangement the hands are not kept in a state of inactivity, and in the progressive recovery of the patient there is no interruption to the play of the fingers when capable of being directed by the will, whilst they are preserved in a state of extension when uninfluenced by the mind.

In all these cases I experience considerable advantage from the stimulus of electricity. This is an agent, which

in its application requires the utmost caution. Determining the charge of any Leyden phial, however small, in any paralytic instance, I have found highly injurious.

It appears probable, from the phenomena of electricity, that the animal fibre, as a conductor, has disseminated through it a portion of this principle: it seems to be the intermediate agent between the vital and corporeal parts of the animal economy. When the influence of the mind is cut off from any portion of the human frame, a violent disturbance of its natural electricity may occasion much mischief, by disorganizing the more minute parts of the system. At first this principle should be applied very gently, inducing at no time more than a wave-like motion of its residual electricity, and progressively increasing the power as the symptoms may dictate. In many instances, we find its application in one direction produces mischief, and, in another direction considerable benefit: this is particularly observable in paralytic affections of the hands and arms. In these cases, whenever I have found electricity beneficial, it has been invariably applied in the direction of the extensor muscles.

In ischiadick, or hip cases, Dr. Falconer has noticed, in his valuable Treatise, the influence of the Bath

**Waters.** In no case is the judicious application of the pump more requisite. When the vessels determined to the affected part have been previously unloaded, and the symptoms indicating an inflammatory action abated, it is then we find warm bathing, with a cautious application of the pump, productive of advantage.

In cases of lumbar abscess, when the tumor has been opened after the judicious mode recommended by Mr. Abernethy, warm bathing, gentle pumping, and, what Mr. Abernethy well terms, electric vibrations, will, in most instances, prevent any further accumulation, directing the stream from different parts by the side of the lumbar vertebræ down to the groin and upper part of the affected thigh.

In obstructions of the biliary ducts, inducing jaundice, and in spasmodic affections of the urinary organs, occasioning suppression, warm bathing is found highly beneficial; and in these cases I always recommend a temperature of two or three degrees above the animal heat: the effects induced, strongly evince the sympathetic connexion existing between the skin and the internal organs. So, also, in various instances of menstrual irregularities, we derive from the warm bath the greatest advantage, and particularly when assisted by electricity.

In short, in most cases depending upon an irregular and disturbed circulation, in every complaint connected with an atonic state of the system, and in every instance where there exists diminished action, warm bathing, by its extensive influence over the whole system, is likely to prove beneficial: as far as it is capable of producing good, it is equally so of occasioning mischief, and requires the same prudent management as any other stimulant employed by the medical character.

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### *The Shower-Bath.*

IN many instances we experience considerable advantage in suddenly diminishing the animal temperature, by a quick abstraction of heat from the surface. This is very conveniently effected by means of the cold shower-bath; and hence very beneficially employed in those cases where we are desirous of lessening the determination of blood to the head. In winter the disturbance of a cold shower-bath is generally more violent than can with safety be borne: hence it is adviseable to commence at about 80 degrees, and to progressively diminish. Gutta

serena, or a defect of vision, arising from some change of structure in the optic nerve, in its incipient stage, is frequently accompanied by a fixed oppressive pain in the head: in such cases considerable advantage is frequently experienced from the cold shower; and when by this, with the assistance of leeches and cupping, if required, the head is relieved, then Galvanism, gently directed through the retina, is frequently attended with the happiest effects.

In the Elements of Galvanism, published by me some years since, from numerous cases in defects of vision, I deduced that little assistance was to be expected from Galvanism. Since that period, at the request of the late Mr. Goldwyer, Mr. Adams of Exeter, and Mr. Lucas of this city, all eminent oculists, I have attempted the ascertainment of the precise power of Galvanism in defects of sight, originating from some affections of the optic nerve.

In two instances of complete blindness, occasioning an incapability of distinguishing night from day, by some months' daily application of Galvanism, I have only rendered the iris susceptible of contraction and dilatation, and the retina so far sensible to the sun or to a vivid light, as to produce a luminous diffusion. In neither case did there exist a power of distinguishing external objects, but the vacant appearance of the eye was somewhat improved.

When blindness is incomplete, in many instances I have arrested the progress of the complaint, and in some induced a capability of reading a small print.

It unfortunately happens, that the unsuccessful cases are also considerable; nor am I acquainted with any mode by which we can previously decide. In so important an organ as the eye, when labouring under an affection which precludes the possibility of relief by other means, it is always adviseable to have recourse to that method which has occasionally proved beneficial, and which (particularly when judiciously applied) is productive of no pain and no possible injury. On the Continent a torturing method is adopted by the application of pointed wires, or by an incision with a lancet, in order to form connecting points with the galvanic apparatus. These are modes of cruelty, not only unnecessary in the application of Galvanism, also injurious by preventing the proper quantum of power being determined through the affected part.

When persons are not far advanced in years, with only small shades of darkness, and little films, or dark spots, floating before their eyes, or the appearance of a tremulous wave like motion—in these cases Galvanism always relieves. Similar good effects are also experienced from its agency in deafness, depending on a defective energy of the auditory nerve.

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CHAP. XI.

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REMARKS ON THE INFLUENCE OF ELEVATED  
OR LOW SITUATIONS.

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AS Bath possesses situations elevated and low, it frequently occurs, particularly in many chronic affections, that the constitution will be materially influenced according to the physical circumstances attending the place of residence. Man is more amenable to the changes of temperature than any other animal: the mind of a person rendered irritable by affliction, becomes additionally fretful, when exposed to a diminished temperature. So much depends upon the nature of the climate where the individual has constantly resided, that in general we find, even in a state of health, changes are evinced by a different situation; and some retain the hereditary character so long, that even in many generations they have

not been familiarized to the climate: thus, Egypt is unfriendly to the Mamelukes; and several European colonies have subsisted more than two centuries in the torrid zone, and experience effects which the natives no ways suffer; the Lascar, on his return, possesses an alertness in proportion to his proximity to the equator. The same circumstances attend the vegetable kingdom: the hardiest plant in the south of Europe cannot be transplanted into a colder climate without an immediate change. The cotton plant is perennial in the warm provinces of America, but only annual in the colder. By a diminution of temperature, there is a corresponding diminution in the force of the circulation of the fluids: man is more sensibly injured by sudden alterations of temperature; we may therefore say, with Hippocrates, *Aër est omnium rex morborum que causa*.

The balancing powers of the constitution are principally preserved by the surface of the body being in a proper state of action; the circulation is uniform from the regular distribution of blood, and the arterial terminations, constituting the exhalants, relieve the system of superfluous fluids, by throwing them off in the form of perspiration. In the exposed surface of the body must be included the air-cells of the lungs, and which unfold a surface exceeding twenty thousand square inches. When we reflect upon this arrangement, we may readily conceive

the derangement that must be occasioned by exposure to a diminished temperature: the cutaneous secretion being lessened, the blood is determined in greater quantities to the internal viscera. This disturbance may produce catarrh, pleurisy, rheumatism, apoplexy, and pulmonary affections. The fluctuating and mutable condition of the climate of the British isles, is the reason why in this country pulmonary complaints are peculiarly prevalent. In all affections of a chronic nature, a mild and equable temperature should always be recommended to the valetudinarian: thus we find that phthisis is hardly known in the West-Indies; and many instances have occurred of this disease being arrested by a removal to a warm climate. Upon this principle it is, that my learned friend, Dr. G. Pearson, of London, has recommended the arrangement of an institution, where an equable degree of temperature should be artificially preserved, for the residence of persons labouring under affections of the lungs. When once the organs of respiration are attacked, they cannot be allowed any rest to assist their recovery, and hence the cells ought not to be disturbed by the admission of air of diminished temperature. Persons thus afflicted should not reside on elevated situations, as the downs of Clifton, or the Upper Crescents of Bath: on these places the range of the thermometer is much

greater than in the lower parts of Bath. We find a more equable distribution of temperature in such situations as the Circus, Pulteney-street, Green-Park-buildings, or the South Parade, than in any of those in the vicinity of Lansdown. An erroneous idea in general prevails, that Bath is improper to the valetudinarian as a summer residence; on the contrary, the lower part of Bath is superior degree to most other places. From local circumstances it is shaded from the excessive heat of the summer sun; whilst, from the admirable arrangements of the pavements, an invalid has every advantage of exercise in a wheel-chair, the use of which the diminished temperature of the winter will not allow.

It is supposed by some, that elevated situations ought to be preferred, from the superior purity of the atmosphere, and from the apparent fogs and mists which envelope the lower districts: very accurate eudiometrical experiments have clearly ascertained, that atmospheric air in every situation evinces the same relative proportion as to its constituent parts; that in the most elevated and in the most depressed situations, the oxygen, nitrogen, and carbonic acid gases, forming the aërial mass, bear the same constant ratio.

Although the influence of the morning sun occasions a greater evaporation from lower districts than from those

situated higher, necessarily arising from the greater quantity of water being determined to the vallies from the surrounding hills, this forms to the observer, on an elevated point, the appearance of a dense unhealthy cloud; if he believe himself in a more salubrious situation, he is not aware that a more unhealthy evening precipitation of moisture occurs on the elevated part. It is well known to those who live in mountainous districts, such as about the Lakes of Cumberland and Westmoreland, that the superior parts of the hills are capped with clouds, whilst the atmosphere about the vallies is perfectly serene. The current of air moving upwards on the sides of a mountain, occasions, by its expansion, a considerable diminution of temperature, from the constant abstraction of caloric; the vapour in the surrounding air becomes condensed, and, from the laws of diffusion, an accumulation forms, and a drizzling precipitation follows. The descending water carries with it the animal and vegetable matter constantly decomposing on the surface of the earth, and which has been volatilized during the day; this is the reason why Margraaf and Chaptal notice, that the evening dews are more unhealthy than the morning fogs, from thus being charged with animal and vegetable substances.

In a comparative point of view, the same changes occur in the less elevated districts; and as the valetudinarian is very susceptible to what would not influence the healthy subject, on every account, both as to the equality of temperature and salubrity of the surrounding air, the lower districts are *cæteris paribus* preferable to the higher.

As temperature is materially influenced by humidity, attention should be paid to the nature of the soil, preferring sandy ground to argillaceous, from being less retentive of water: so, also, a residence should not be surrounded by trees; they prevent the influence of the sun, and at the same time, by the great evaporation from their foliage, the house is enveloped with a cloud of moisture. From these circumstances woody and marshy countries are always cold; and the temperature increases in proportion to the cultivation. Thus ancient Germany corresponded to modern America; for, until the Hercynian forest was removed, the cold was very excessive.

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## CHAP. XII.

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### ON INCURVATIONS OF THE SPINE.

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**I**N a volume of Philosophical and Physiological Essays I published about twelve years since, I attempted to explain the admirable structure of the spine on geometrical principles, and the mode of ascertaining the powers of mechanism in any deviations of the vertebræ from their natural course.

The favorable reception which these essays experienced from some of the leading professional gentlemen of the metropolis, was the cause of a great number of cases of every denomination and character, where diseased spine was concerned, being presented to my attention.

From these numerous applications, I was induced to examine minutely the principles of construction of all the different species of mechanism which had been employed for this purpose, either on the Continent or in our own

country, I perceived that one universal principle pervaded every spinal apparatus, and the same indiscriminately adopted in every case.

The instrument of Vachers, which seems to have received no improvement from the labors of Jones and others, forcibly suspends the head under an iron arch; in very few instances can the slightest advantage possibly result from its use. I have remarked, in many cases, inconveniences of a very serious nature to arise from the constant pressure on different parts of the head, and from the muscles of the neck being retained in a state of constant inactivity.

From a well-known principle in mechanics, of action and re-action being equal, it is evident that, in proportion to the weight the instrument has to support, so the parts on which the instrument presses must be acted upon. In a suspensory gibbet-like apparatus, the supporting powers are directed to the back of the head, the temples, or under the chin.

When the instrument has been worn for some time and removed, however the spine had been apparently elevated when under the influence of the apparatus, immediately the body sinks down to its original state, with the additional inconvenience of the head falling forwards,

from the muscles appropriated to its support having lost their powers of action.

From the constant pressure on the temples, the circulation is so much disturbed, as in general to induce very oppressive head-achs; and when the supporting bandage is placed under the chin, the features become frequently distorted. As in these cases it is requisite, in many instances, for an apparatus to afford any efficient relief, to be worn a considerable length of time, it is of the highest importance that the ease and comfort of the patient should be consulted, and the least restraint possible during its application be occasioned.

As many of these cases are connected with constitutional debility, to the aid of mechanism we must contribute every thing in our power that may tend to the general strengthening of the system; to consider any mechanical means which may be adopted, only to be continued until the supporting powers of the human frame are capable of answering their intended purpose.

This restoration to health is greatly impeded, when the natural motions of the body are so restrained as to preclude the indulgence of that exercise, which is absolutely necessary in affections of this kind.

We find in many instances, particularly in delicate females, where the incurvation is but slight, that the

dread of an apparatus, so distressing in its application and general exposure, prevents recourse being had to any professional assistance.

It fortunately happens, that more powerful support, in most instances, can be given, without the human frame being subjected to the slightest restraint, and its application continued without being known to any other that such an instrument is worn.

The true vertebræ of the spine consist of twenty-four bones, and between each adjoining vertebræ there is interposed a substance participating of the nature of a ligament and of a cartilage, forming a soft and yielding fulcrum which enables the vertebræ to move easily in any direction, and protects the body from the effects of violent shocks.

In consequence of these numerous joints, extensive motions to the body are allowed, without any danger of compressing either the spinal marrow or the nerves and blood-vessels connected with the vertebral column. In delicate constitutions, particularly in the slightly-formed frames of females, if an unsupporting sedentary position be indulged in, we frequently find a deflection of the spine from its proper course; and whenever any morbid curvature is made, a second deviation in an opposite direction must be formed.

These preternatural curvatures, depending on constitutional debility, are at first lateral, and subsequently convex; a change which can only result from inattention to the affection in its early stage. In these cases, all the vertebræ become more or less displaced: as the curvature increases, the spinal column proportionally loses its capability of supporting the weight of the body, and the whole trunk in the same ratio becomes more distorted. Every delicate child should from time to time be carefully examined, whether the scapulæ or shoulder-blades be perfectly even; whether there exist any difference in the hips, or whether there be more roundness on one side of the chest than on the other; if so, there is probably an incurvation of the spine, or a disposition to it, which, by timely attention, may be effectually cured.

We frequently see an inclination of the body to one side, independent of any constitutional affection, merely the result of habit; and this alone has frequently led to very serious incurvations.

The animal body, during its growing state, will be influenced in its direction by the more prevailing position; and hence, the most serious attention ought to be paid as to the position to which a child accustoms itself.

As health is a primary object of consideration, the advantages of education, in some instances, are better

deferred, than permitting a child to preserve, for some hours, an uneasy posture on a form, without any support to its back; for its own ease it will naturally be disposed to bend on one side, and thus influence the future growth of the body.

A delicate child should never be allowed to write on a low table or desk, which may require the body to be placed in a bent position: from this cause alone considerable mischief frequently arises.

When once an incurvation of the spine has taken place, the mischief is not confined to its powers as a supporting column; it also occasions an alteration in the natural arch-like form of the ribs, a form intended by nature as a protecting medium to the thoracic and abdominal viscera.

In every spinal affection we soon observe its influence on the chest; its capacity becomes diminished, the action on the lungs becomes proportionately restrained, and a disposition to pulmonary complaints follow.

It is to this cause that Dr. Darwin attributed the deaths of a greater number of females than males, from phthisis pulmonalis, or consumptive diseases. As, in the growing child, nature should be left unrestrained; so, tight clothing, strong stays, braces, and back-boards, should be studiously guarded against.

When, at the first period of incurvation, the spine in the affected part assumes a convex form, it constitutes a complaint by no means connected with any debility of the system, but originating from some local injury, characterizing the disease which was the subject of Mr. Pott's attention.

Upon dissection it appears, that in most instances the disease originates in the ligamento-cartilaginous substance, the intervening bed between the respective vertebræ; it takes on inflammation very slowly, and, when under this state of action, is equally difficult to be removed. In almost every instance we trace the cause to some local injury; to some fall the child has experienced during its nursing period, and, in most instances, from the circumstances being kept concealed from the parents. Every nurse ought to have her mind strongly impressed with the necessity of communicating to the parent the particulars of any accident to a child, as a fall, &c. which may have occurred, in order that an early examination may be made, and the mischief, that would otherwise ensue, be timely averted. It unfortunately happens, that the effects of a fall apparently soon terminate; and the nurse, from a fear of being reprehended for carelessness, will keep the circumstance concealed. It is adviseable in every parent seriously to enforce the necessity, to any nurse that may be employed,

of candidly communicating to the parent any accident of this kind, without an apprehension of subjecting herself to censure.

In almost every case of spinal affection of this character which has been under my care, I have ascertained its cause to have been a local injury.

Mr. Pott, and many other eminent practitioners, deemed the disease scrofulous, and supposed it connected with constitutional disposition: certainly in many instances I have observed this complaint unconnected with any apparent affection of this kind, and where it could only be attributable to the local injury impressed on the part.

When the injury, in its earlier stage, has not been attended to; when the disease has arrived to that extent as to have induced an ulcerative process in the substance of the contiguous vertebræ; there is no doubt, that if there exist a scrofulous pre-disposition, such may be called into action; and it is probable, that, in dispositions of this kind, the same quantum of injury may induce more violent effects.

As the intervertebral substances are fixed to the bodies of the vertebræ, it is evident, from local circumstances, that when this intervening medium is destroyed by ulceration, the bodies of the contiguous vertebræ must approximate, and occasion a protuberant convexity externally.

The centre of the concentric lamellæ, of which this protecting cushion is composed, constitutes the pivot upon which the other parts move; when destroyed, the centre of motion is transferred to the bodies of the vertebræ, which, from their spongy nature, are not calculated for resisting media; the ulcerative process is to them transmitted, and, by the super-incumbent weight, increased.

Although the intervertebral substances, like the vertebræ themselves, are larger and thicker as they descend, in order to give greater security to the parts they support, yet, in the list of this species of deceased vertebræ, there are more affections of the lower dorsal and the lumbar than of those superiorly situated.

As the disease increases, the spinal canal proportionately varies in its direction; the medulla becomes compressed, and all the nerves detached from the spine below the affected part lose their energy, and a paralysis of the inferior extremities follows.

In the treatment of this complaint, Mr. Pott recommended issues, or setons, on each side the affected vertebræ; and, to preserve as much as possible a recumbent position, a position in some respects regulated as to its direction by the seat of the complaint.

Vain would be our attempts in arresting the ulcerative process, if we permit the bodies of the affected vertebræ

to be in contact with each other; and hence a nice adjustment, as to position, is requisite, and which should be varied according to the injured part of the spine.

In the more advanced stages of the disease, and particularly when the lower extremities are inadequate to the support of the superincumbent weight, a recumbent situation becomes absolutely necessary, and then blisters, issues, or setons, may, by the action they induce externally, remove the morbid action situated internally.

Every parent, who confides her child to the care of a nurse, to guard against such melancholy complaints, should occasionally examine the back, tracing the finger with some degree of pressure along the course of the spine, and carefully observe whether there be any peculiarly tender part; if this should be remarked, there will be reason to apprehend some injury, and recourse should be had to professional advice. At an early period, rubbing the part with a gently stimulating embrocation, and letting the child indulge occasionally in a recumbent position, in general are found to be sufficient preventatives.

If the disease should increase, the weight of the upper part of the body should be abstracted, which can be conveniently effected by a simply-constructed mechanical contrivance that merely acts as a portable crutch, whose bearing is principally upon the crista of the os ilium of

each side, and elevated to that degree till the whole weight of the trunk and superior extremities be transferred from the spine to the instrument. By this simple contrivance, all irritation arising from superincumbent weight is removed, and topical applications may then be employed, with every prospect of success.

In the more advanced stages, when the inferior extremities are partially or completely paralysed, very little advantage can be derived from mechanical means; our principal hopes depend upon a proper recumbent position, and the adoption of those remedies which the symptoms will dictate: if, by a continuance of this mode, the lower extremities should be so far restored as to admit, for a short time, the support of the upper part of the body, we then find considerable advantage by protecting the affected vertebræ, by means of the apparatus I have already alluded to, and a change of position so conducive to the recovery of health may then with safety be longer indulged in.

In these spinal affections, when the patient has been kept in a horizontal position for many months, and, in some instances, a year or two, under the exhausting irritation of setons and issues, it is no wonder that so many sink under the mode of treatment; by availing

ourselves of the assistance mechanism can afford, we considerably shorten this period of misery.

A remarkable instance of the advantages to be derived by mechanically taking off the bearing of the upper part of the body, occurred to me some years ago in the daughter of a Capt. Creighton, who was placed under my care by the late Mr. Sheldon, of Exeter: the disease existed between the first and second lumbar vertebræ; and about a week before I saw her she had considerably lost the power of controlling the motion of her legs, and was under the necessity of supporting herself by a stick. After applying a spinal apparatus and adjusting its elevations, and thus removing any pressure on the nerves, the power of command, as to the limbs, in seven or eight days, was completely restored.

In the more simple affections of the spine, where the deviation is the result of habit or of general debility, our attempts should be directed to the preservation of the sides in a parallel direction, being cautious that the elevating part of the apparatus be only applied to the side which is bent in.

By preserving the sides in this state of parallelism, if the growth should not be completed, the future extension of the body will be regulated in its proper direction, and the parts previously incurvated considerably corrected.

In cases where persons are arrived at maturity, and an actual change of structure has taken place, although all hopes of restoration are removed, yet some important advantages from mechanism are to be derived; not only the appearance is considerably improved, by the shoulders being preserved in an equal degree of elevation, also from the general support given to the trunk and superior extremities, the sensation of fatigue, which is otherwise soon experienced, is prevented, and a continued diminution of the capacity of the chest materially obviated.

In almost all these cases, every assistance that mechanism can afford may be so arranged, as not to subject the wearer to the least possible restraint, and without being known to any other person.

Dr. Tronchin, of Paris, notices considerable advantages he experienced, from placing on the head heavy substances for the patient to carry about; the Doctor supposed the incurvation to arise from muscular debility, and that he should give strength by calling the muscles into greater action.

In the incipient stage there is very probably no change of structure; and hence some advantage may be derived from this plan in very young subjects; and particularly, as Mr. Petit observed, if the weight on the head, such as a loaded basket be supported by the hands, in this position, the shoulders become equally elevated.

This can only act temporarily, as a young person could never be expected to carry a weight on the head for any considerable length of time; and it is probable that, in cases of actual distortions of the spine, there would be more injury, from the increase of superincumbent weight, than advantage from change of position.

In all these cases it is necessary that a recumbent position be indulged in, various times in the course of the day. We find that the ligamento-cartilaginous beds, between the vertebral bodies, are so yielding as to be capable of being condensed; and hence, by a long-continued support of the body, these intervening substances become more compact and thin, and is the reason that we are taller in the morning than in the evening; from which we deduce the necessity of an occasional horizontal position, in morbid affections of the spine, to relieve these intermediate cartilages from pressure.

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CHAP. XIII.

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ON THE ADVANTAGES TO BE DERIVED FROM  
MECHANISM IN VARIOUS CORPOREAL  
AFFECTIONS.

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**I**T unfortunately happens, that the professional engagements of medical gentlemen prevent their paying the requisite attention to cases which can only be relieved by mechanical means; and hence they are confided to the management of a common instrument-maker, who cannot be expected to possess any knowledge of the natural structure of the human body, or a capability of varying the principle according to existing circumstances.

The principal objects to attend to in the construction of any mechanical apparatus for the relief of corporeal affections are, that the lever or sphere of action should be as extensive as can be conveniently adopted, for the larger the surface acted on is, the less pain will be experienced; that the apparatus be constructed of such materials as to combine lightness, strength, and simplicity; and that the adjustment be such as in no instance to give

pain, observing, that a deviation from the natural form can never be remedied by violent means.

In cases depending on muscular defects, care should be taken to ascertain which muscles are affected, whether the extensors or flexors, that the mode of treatment may be regulated accordingly.

It ought always to be observed, that when a change of structure has taken place, and the growth completed, that a complete cure by the aid of mechanism is not to be expected.

These principles I shall attempt to illustrate by cases of that description which have been frequently presented to my attention.

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#### WRY-NECK.

IN general this is occasioned by a morbid contraction of the fibres of the sternocleido-mastoideus muscle on one side, so that the elastic powers are completely destroyed; and no mechanism can correct this diseased rigidity of fibre. Within these last two years I have had three cases, where no permanent contraction existed in the fibres of either side, and when the head was left un-

restrained, the muscle on one side the neck, acting more powerfully than its antagonist, occasioned the face to be turned in a minute towards the shoulder. Embrocations, blisters, electricity, &c. had been applied to the apparently-affected part without any advantage, and in one instance with marked injury. The first object is to restrain the too active muscle, which is easily effected by a simple bandage made of ribbon, and to stimulate by electricity the antagonist muscle, so as to bring the sternocleido-mastoideus muscle, on each side of the neck, into an equal state of action.

In this, as in every instance depending on defective muscular action, before any medical attempts to restore the affected part to its proper state are made, the muscles should be placed in their natural positions, and retained by mechanical means, otherwise attempts to restore the debilitated fibres to their natural tone are generally fruitless. Similar circumstances attend the flexion of the fingers, and depression of the toes in paralytic affections of the muscular organs, where sensibility is retained: in these instances we experience considerable advantage, in giving to the extensor muscles their requisite degree of support, otherwise they are kept in such a constant state of tension as to be rendered incapable of recovering their contractile powers.

## ON TRUSSES FOR HERNIÆ OR RUPTURES.

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A truss we are to consider as an instrument to be worn a great length of time, and, therefore, ought particularly to attend to that construction which will give the proper support with the least degree of uneasiness. In that species of rupture which is the most prevalent, viz. the inguinal hernia, the apparatus commonly worn seems to have been constructed contrary to every principle of mechanism. In the first place the pad is made small, rising to a point and descending, whilst the spring is spirally directed upwards, from an idea that it should act above the crista of the iliæ. The principle of a spring is not reducible to any of the common mechanical powers; on which account, in a Philosophical Analysis of Lectures, which I occasionally deliver, and lately published, I have ventured to propose the spring as a seventh mechanical power. Very little attention to a spring is required to perceive, that the longer it is, the weaker is its power; and that the points of action of the spring should lie in the direction of the spring itself. These

properties are counteracted by a spiral direction: the pad should be uniform on its surface, and so adjusted, with respect to the spring, as to be accommodated to the obliquity of the abdomen in that part; a circumstance particularly necessary in persons inclined to corpulency.

In many cases of rupture we are to consider, that a truss, properly constructed, is not to be deemed merely as a palliative remedy, but, in many instances, as a radical cure. By long-continued pressure, the orifice through which the intestine has protruded becomes gradually diminished in size, producing a thickening as well as diminution of diameter, that nothing will descend, and, in some instances, so contracted as not to admit of a probe. To produce this desired effect, we are to consider that the orifice of the sac is not situated within the ring, but two inches above it, obliquely; and hence, when the contents of a hernia are returned into the abdomen, the pressure of the pad should be directed to the orifice of the sac, and not to the orifice of the ring; and it fortunately happens that a truss thus applied, and the spring acting on the dorsum, or external broad side of the ilium, is equally superior in ease as in effect.

When the pad is properly placed over the orifice of the sac, the spring should be carried round under the crista of the ilium, not so low down as to admit of being

displaced by the action of the glutæi muscles. The length of the spring should be regulated according to the circumstances of the patient's employment; if his occupation should require considerable corporeal exertion, the spring should go nearly round, otherwise it need not extend beyond the spine; an intermediate length would occasion the edge of the spring to press on the glutæi muscles, and every time they are in action the pad would be displaced.

After wearing a truss, if the mouth of the sac have been contracted by its pressure, the greatest care is required in leaving off the instrument; in case of a protrusion there is more danger of a strangulation of the intestines than before. Hence, a truss should be continued for some time after the patient is apparently well.



CONTRACTED LIMBS FROM AFFECTIONS OF THE  
OS ISCHIUM, OR HIP-BONE; ANCHYLOSIS  
OF THE KNEE-JOINT, &c.

IT is generally stated, that the diseases denominated hip-cases depend on a scrofulous disposition. I am induced to suppose, from a great variety of cases, that there exists an analogy between these complaints

and the affections of the vertebræ depending on local injury. We find diseases of the hip-joint more frequent in young persons than in adults: at first, like diseases of the vertebræ, the pain is but trifling, the progress very slow, and at first appears with walking indifferently; soon after, the limb on the diseased side is a little longer than the other, owing to an accumulation of fluid in the inside of the joint, thrusting the bone a little forward: this elongation only continues for a short time, and afterwards becomes considerably shorter. In the first instance the membranous parts take the diseased action; afterwards the head of the thigh-bone becomes ulcerated, and the *ligamentum teres*, or *rotundum*, and the capsular ligament become similarly affected. The attachments of the os femoris to the acetabulum being destroyed, the pressure of the body occasions the head of the thigh-bone to be forced upwards and backwards on the os ilium, and thus produces a considerable shortening of the limb.

Dr. Falconer has remarked, that in ischiadic cases considerable advantage has been derived from the topical and general application of the Bath Waters, and particularly if employed in the early stage. When we examine these cases after death, there is every appearance of the disease originating in the membranous lining; the same as is observed in the knee-joint, or in the intervertebral

ligaments by some percussive force. In the first stage the pain is not violent; and whenever a child complains of any uneasiness in the hip, by early attention the disease may be prevented. It is evident that the weight of the body is divided between the femoral bones; and, in walking, the pressure upon an injured membrane must necessarily aggravate the disease. The child should be preserved in a recumbent posture as long as the slightest pain remains; cupping, leeches, and blisters, should be topically employed, and when the child is permitted to walk, an apparatus should be adjusted to prevent the slightest bearing upon the thigh-bone of the affected side, and continued for many months.

If the inflammation increases, there is an increased secretion from the lining membrane. This accumulation of fluid, by its pressure, occasions an ulceration on the head of the thigh-bone; and unless favorably terminated by an anchylosis or stiff joint, the capsular ligament becomes destroyed, and an abscess is formed, which must be carefully distinguished from a lumbar abscess.

In every stage of this complaint, either a recumbent position, or a mechanical apparatus for abstracting the weight of the body on the affected thigh, must be constantly attended to; otherwise all attempts for the protection of the constitution, from the excessive irritation induced by this complaint, would be useless.

When the morbid action has so far terminated as to allow of walking without inducing pain, it becomes then of importance to consider the circumstances that may, from the shortening of the limb, affect the other parts of the body. When these occur in an early period of life, which is most frequently the case, the constant inclination of the body to one side will induce an incurvation of the spine, and all its concomitant evils; hence it is necessary that the parallelism of the body should be preserved during the growing period.

In morbid affections of the knee-joint, terminating in ankylosis, the limb is generally more serviceable, if, during the progress of the disease, the leg be preserved in an extended position; by this method the flexor tendons are not only prevented from acquiring that rigid contraction which is observed in these cases, the limb also is of a proper length and precludes the necessity of any mechanical apparatus for the equalization of the body; in cases where the stiff joint has been found in the bent state of the knee, it is necessary to have a support, the construction of which must be regulated according to the flexion of the limb.

## CLUB-FEET.

RELATIVE to the treatment of club-feet we are indebted to some valuable observations of Mr. T. Shel-drake. In general, we find this species of incurvation to depend principally on the position the tarsal bones have assumed in the foetal state. In the new-born infant, the seven tarsal bones are only partially ossified, principally of a cartilaginous character, and connected to each other by ligaments. At an early period, any deviation from the natural form becomes easily corrected: we have only to overcome the resistances arising from the ligaments and muscles, and retaining in its proper direction the limb, until the future growth enables the respective parts to exercise their natural power.

In some respects, whatever influences the lower end of the fibula will produce some change in the direction of the foot. The curvature observed in this bone depends materially on muscular action, and is very frequently increased by nurses holding children carelessly by the legs.

In case of club-feet, when attended to in the early stage, little more is required than a simple bandage, taking care to apply it in that manner as to keep the gastrocnemii muscles in a state of extension. When a child has been allowed to continue two or three years in this state, the

bones are then converted into resisting media, and their formation is influenced by the position in which they have been preserved. In these cases we find the bearing is on the outside of the foot; the lower part of the fibula, forming the malleolus externus, or outer ankle, considerably projecting, whilst that part of the tibia, which constitutes the inner ankle, disappears in a proportionate manner.

In these cases, the gastrocnemii muscles, by the strong attachment of the tendo achillis to the os calcis, being in a state of flexion, draw up the heel; and as the projection of this bone from the tibia is considerable, the resistance is proportionally increased.

In an affection of this kind we must not only correct the lateral pressure of the foot, also employ a counteracting power to the action of the elevating muscles of the heel, so as to bring the os calcis into a more horizontal direction. We derive considerable assistance by a steel plate applied under the foot, extending from the heel to a little beyond the toes: at this extreme point we have a great length of lever, which will enable us, by means of common straps, powerfully to draw down the heel, regulating our power according to existing circumstances; and always remembering, that the agency of every piece of mechanism, employed in correcting any corporeal defects, must be so adjusted as to produce the requisite change by

slow and progressive means. Whenever the action of any apparatus is violent, or considerable pain induced, all the expected beneficial effects become defeated. Almost every part of the human frame may be influenced with safety as to a change in its direction, when the means employed produce no painful disturbance by their power of action. I have seen some cases of club-feet, at the age of ten or eleven, which, by proper perseverance, have been so far corrected as to enable the patient to walk without much inconvenience.

# APPENDIX

## THE HISTORY OF THE

### REIGN OF

THE GREAT KING OF GREAT BRITAIN

AND OF THE KINGDOM OF IRELAND

FROM THE YEAR 1714 TO 1760

IN TWO VOLUMES

THE FIRST

OF THE REIGN OF

GEORGE THE SECOND

# LECTURES

ON EXPERIMENTAL

PHILOSOPHY and CHEMISTRY.

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**E**VERY Monday and Friday, from the middle of November to the close of May, precisely at one o'clock, Dr. Wilkinson delivers, in his Lecture-Room, adjoining the Kingston-Baths, a series of practical Lectures on the different branches of Experimental Philosophy, Chemistry, and Mineralogy. In these lectures such subjects are selected which admit of the more useful applications to the purposes of life; for the illustration of which Dr. Wilkinson has arranged a laboratory and an appropriate philosophical and chemical apparatus.

As electro-chemistry is now rendered peculiarly interesting, from the great and surprising discoveries made by Professor Davy, particular attention will be paid to this new branch of science, and for this purpose an extensive galvanic apparatus is provided. From the labors and

genius of this illustrious professor, many operations in nature, highly interesting to the mineralogist and geologist, the causes of which were involved in so much obscurity, appear to be now happily unfolded; and the results promise that we may not only protect ourselves from the direful effects of these powerful agents employed by nature, but even direct them to purposes highly beneficial to society.

*Private Lectures.*—Any number of ladies and gentlemen in a family not less than six, preferring private instructions to a public course, in order to have the opportunity of trying the experiments themselves, and of making those enquiries which a popular course will not admit—on application to Dr. Wilkinson, arrangements will be made accordingly.

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#### SOILS AND MINERALS.

AS the analysis of soils and minerals has frequently proved highly advantageous to the agriculturist and the land proprietor, to every gentleman of liberal education, a knowledge of the principles by which their respective component parts may be separated must be highly interesting. Thus, to the agriculturist, when collateral circumstances relative to different lands are the same, the

products will depend on the constituent parts of the soil. When their local conditions differ, every thing relative to situation, temperature, quantity of rain being ascertained, from the known properties of the different earths, arrangements most conducive to fertility may be made. So, also, with respect to the mineralogist, such enquiries are of the highest importance: when we reflect how much the welfare of this country depends on the riches discovered in the interior of the earth; on the coal, iron, lead, copper, tin, and zinc; how, by the aid of these, our manufacturers, notwithstanding the superior price of labor, are enabled to enter into competition with foreign markets; it must appear obvious that the principles of mineralogy merit the most minute attention.

It cannot be expected that every gentleman of landed property can devote the requisite time for acquiring the mode of minutely investigating the constituent parts of a compound mineral; it is only the more prominent characters he is desirous of understanding, that he may ascertain the value of what may be found on his own estate, and, at the same time, protect himself from the plausible schemes of speculative adventurers.

Gentlemen desirous of directing their attention to these subjects, may receive private instruction on appli-

cation to Dr. Wilkinson, where a laboratory is provided with every requisite apparatus which the analyses of soils and minerals may require.

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#### GEOLOGICAL AND MINERALOGICAL COLLECTIONS.

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DR. Wilkinson, having for some time directed his attention to an arrangement of fossils and minerals, with a view to assist the geologist in his enquiries relative to the structure of the earth, purposes to adopt the plan recommended by his friend Mr. W. Smith, of placing in their respective order those fossils which are peculiar to, and are only found lodged in, certain strata; he has to request the kind assistance of his friends to enable him to complete a plan, from which, he flatters himself, considerable utility will be derived.

The collection will be placed in the Kingston Pump-Room, (open to every person) with descriptive names to each specimen; and as soon as the number of fossils will admit of their proper stratified arrangement, such will be immediately adopted. Many families are in the possession of a few specimens, which answer no immediate scientific object, and which may considerably enrich a collection now attempted to be formed for public purpose.

Any gentleman, desirous of ascertaining the component parts of a mineral, a proper specimen sent to Dr. Wilkin-son, with particulars as to the place in which it was found, the nature of the stratum, and the direction of the vein, will be informed by Dr. W. without any additional expense charged than of the materials employed.

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TERMS OF THE KINGSTON BATHS AND  
PUMP-ROOM.

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For a private bath .....	0	2	6
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Two ladies in one bath .....	0	3	6
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These charges include the pumper. A woman is employed to rub after Mr. Grosvenor's plan.

#### ADDRESS TO INVALIDS.

AS there are many persons in the middle spheres of life who are deprived of the advantages they may derive from the Bath Waters &c. on account of the many incidental expenses, Dr. Wilkinson begs leave to submit to them the following plan, which, from the peculiar nature of his situation, he is enabled to submit to their attention.

For medical superintendence at his own house, the use of the hot, tepid, and shower baths, wet or dry pumping, drinking the waters, &c. daily, if required—all expenses included in one guinea per week.

Galvanism or electricity medically employed, £1. 11s. 6d. per week. No additional charge for bathing and drinking the waters.

## APPENDIX.

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SINCE the printing of the first sheets of this work, I have had an opportunity of making a tour through Cornwall, and am thus enabled to correct some errors relative to the strata mentioned in pages 15 and 16. Killas I erroneously stated to be an alteration of the term gneiss: upon examination it appears to be an argillaceous schist, and tin is more frequently found in it than in granite: in general, copper mines are deeper than tin mines; and, in many instances the tin lode terminates in the commencement of a copper lode; and not unfrequently the metals are mixed together. In all shafts of considerable depth the water is very warm: at the same corresponding depth the spring in a copper mine is warmer than the spring in a tin mine; probably this additional heat may be occasioned by the agency of the sulphuret of copper on the water.

In page 43 I noticed a slight shade of difference in Dr. Falconer's table of the specific gravities of the waters

in Bath, together with the results of my experiments. Dr. Falconer, with that liberality which ever characterizes the gentleman of true science, revised his former experiments, and discovered a small source of error, occasioned by the stand of the glass in which the experiments had been conducted, having been a little ground without the loss of weight being noticed.

FINIS.

# THE FOLLOWING WORKS,

WRITTEN BY DR. WILKINSON,

*May be had of the different Publishers.*

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# REVIEWERS' REMARKS.

"The reader will find, interwoven with the first principles and fundamental experiments of Galvanism, a considerable body of useful information, related in a pleasing manner, without ostentation, and yet free from any thing low and mean."

*Imperial Review.*

"This work may be considered as presenting an accumulation of valuable facts relative to the promulgation, establishment, progress, and present state of Galvanism; and as holding forth reasonable expectations of the most important advantages to be derived from its further cultivation."—*European Mag.*

"In two octavo volumes, illustrated with many curious plates, the learned lecturer illustrates the doctrine of Galvanism in a scientific but clear detail, which we recommend to the perusal of our readers."—*Gentleman's Mag.*

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